Portland Harbor Superfund Site
Draft Feasibility Study Report

March 2012

EXECUTIVE SUMMARY

LWG
LOWER WILLAMETTE GROUP


Sauvie Island
COLUMBIA RIVER
COLUMBIA SLOUGH
Hayden Island
MULTNOMAH CHANNEL
SMITH AND BYBEE LAKES
LWG Study Area
St. Johns Bridge
Railroad Bridge
Willamette River
LEGEND
Federal Navigation Channel
1 River Mile
Portland
OREGON
Fremont Bridge
Broadway Bridge
Steel Bridge
Burnside Bridge
Downtown Portland
1
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Project Overview

After more than 10 years of investigation and analysis, the Lower Willamette Group (LWG) has prepared a draft Feasibility Study (FS) for review and approval by the U.S. Environmental Protection Agency (EPA). The draft FS (along with the previously submitted draft final Remedial Investigation) provides the framework for EPA to select the remedy for cleanup of sediment contamination in the Portland Harbor area of the Lower Willamette River.

This Executive Summary outlines the extensive data and analyses prepared by the LWG with EPA oversight. It is a guide to the findings of the draft FS but represents only a portion of its detailed and thorough evaluation of alternatives that will provide EPA a path forward to prepare a Proposed Plan and Record of Decision (ROD), which will document the selection of cleanup actions that will protect human health and the environment.

The draft FS is one of the key steps in the Superfund process to determine how risks to human health and the environment from sediment contamination can be reduced. The draft FS is the "toolbox" from which EPA will select the remedies for the harbor-wide cleanup of the Portland Harbor Site.

As detailed in the evaluations presented in the draft FS, developing an efficient, coordinated, and effective sediment remedy for the Site as required under the National Contingency Plan (NCP) will be a complex undertaking. Evaluations using NCP criteria of the wide array of comprehensive alternatives (all of which are protective over the long-term) highlight tradeoffs associated with different cleanup strategies that could potentially be applied to the Site.

The LWG worked closely with EPA and its other government and Tribal partners to prepare the draft FS, including development of detailed remedial action objectives (RAOs), areas of potential concern (AOPCs), and a list of technologies to aid in the development of the remedial alternatives. The draft FS uses these key components to develop remedial goals (RGs), remedial action levels (RALs), and sediment management areas (SMAs).

BRIEFLY

The Challenge:

- Four different groups of contaminants of concern (COCs), polychlorinated biphenyls (PCBs), dioxin/furans, the pesticide dichloro-diphenyl-trichloroethane (DDT) and related breakdown products, and polycyclic aromatic hydrocarbons (PAHs) pose most of the estimated potential human health and ecological risks at the Site.
- These contaminants are primarily related to historical releases and (along with the toxicity to benthic organisms [e.g. sediment dwelling organisms]) are considered bounding contaminants because they account for most of the areas posing potential risks at the Site. Other contaminants are present within these areas as well as in other localized areas. Contaminants within the Site are also found upstream.
- Ingestion of resident fish (e.g., smallmouth bass) is the primary risk exposure to humans and aquatic mammals. Consuming migrating fish (e.g., salmon) does not pose similar risks to people.
- Other exposure pathways, such as direct contact with sediment or water, present much lower risks to people. Recreational use exposures are within EPA's acceptable risk ranges.

The Solution:

- Alternatives for site-wide sediment cleanup were developed using the full suite of technologies and EPA-approved RALs in the draft FS. Twelve alternatives everything from taking no action to large-scale dredging actions throughout the Site were evaluated.
- Alternatives B, C, D, E and F each have two options:
  - *"r" removal-focused* — places more emphasis on removal and disposal by dredging more of the river along with limited capping, in place treatment, and monitored natural recovery; and
  - *"i" integrated* — using a combination of removal (dredging and disposal), capping, in place treatment and monitored natural recovery.
- Of the eleven alternatives fully evaluated Alternatives B-i, C-i and D-i best meet both the remedial action objectives (RAOs) and the National Contingency Plan (NCP) evaluation criteria. Compared to other alternatives these three alternatives achieve risk reduction in substantially shorter construction durations.
- These three alternatives have far less short-term impacts on the environment during remedy implementation, less impact on the community, and less impact on harbor businesses during remedy implementation.
- Of these three alternatives, Alternative B-i is protective for the least cost (it scored high in terms of short- and long-term effectiveness, reduction in toxicity, and implementability, while representing the lowest range of cost), while Alternative C-i scored the highest in terms of these criteria without consideration of cost.

Progress to Date

For more than a decade, the Portland Harbor Superfund Site has been the focus of one of the most comprehensive scientific studies and analysis of sediment contamination in any major waterway.

Named in 2000 by EPA to the National Priorities List for cleanup, approximately 11 miles of the Lower Willamette River is currently designated as the Portland Harbor Superfund Site study area. In 2001 EPA and the LWG signed a legal agreement to guide the Remedial Investigation and Feasibility Study (RI/FS) process.

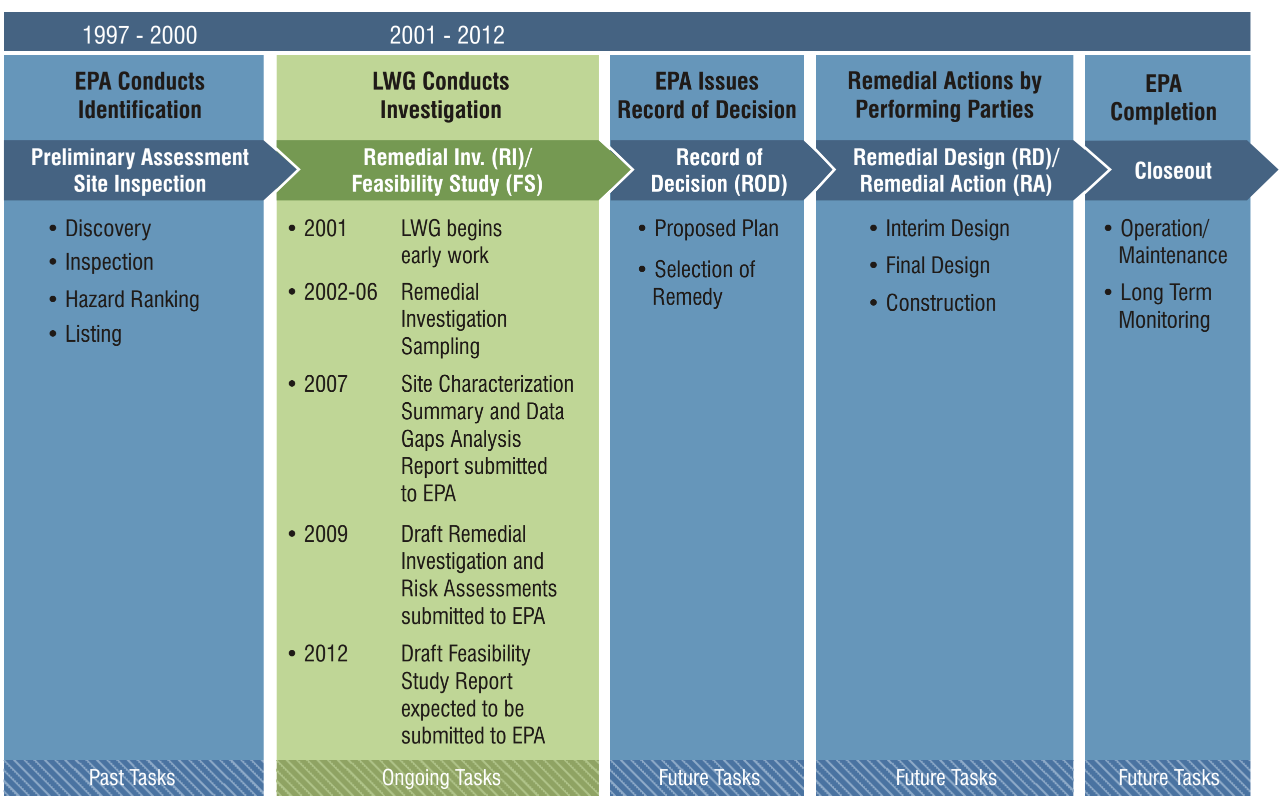
The LWG prepared the draft Remedial Investigation (RI), including human and ecological health risk assessments, and submitted it to EPA in 2009. EPA reviewed the draft document, and LWG submitted a revised RI in 2011. The EPA is now reviewing that document. The LWG expects to finalize the RI in 2012. EPA and the LWG have agreed to proceed with a draft FS while finalization of the RI continues.

The draft FS does not determine who is responsible for the costs of cleanup, nor does it define cleanup boundaries, select specific technologies or choose sediment disposal sites. EPA will prepare a Proposed Plan for public review and then issue a Record of Decision (ROD) that describes the cleanup in greater detail.

The draft FS provides EPA the tools to answer the following questions about Portland Harbor sediments:

- What and where are the potential risks to human and environmental health?
- What are the best ways to reduce them?
- How much time and resources will it take to implement the sediment cleanup?

Figure 1 Portland Harbor Superfund Site Process



Sources of Contamination

Much of the sediment contamination in the Site is associated with historical sources and practices that have largely been discontinued or otherwise controlled. The Oregon Department of Environmental Quality (DEQ) is working with EPA on control of remaining known sources in the Site before construction of the Portland Harbor Superfund Site cleanup remedies.

Remedy Selection Criteria

The federal Superfund regulation (known as the National Contingency Plan or NCP) uses nine criteria for remedy selection (see inset box). The first two (protectiveness and compliance with laws) are "threshold" criteria that must be met. The next five are used as "balancing" criteria to assess the advantages and disadvantages among the proposed remedies, particularly in terms of effectiveness, implementability and cost. The final two are "modifying" criteria, which includes state and community acceptance. As required by EPA guidance, the draft FS considers the first seven criteria, and EPA will consider the last two.

Superfund Remedy Selection Criteria

Two threshold criteria
1. Protect human health and the environment
2. Comply with federal and state laws

Five balancing criteria
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost

Two modifying criteria
8. State acceptance
9. Community acceptance

Cleanup Levels

Sediment cleanup levels will be based on the site-specific human health and ecological risk assessments. In selecting final sediment cleanup actions and remediation levels, EPA will also consider risk management factors. Per EPA regulation and guidance, the background concentrations of contaminants are an important consideration for selecting final cleanup levels.

Cleanup Alternatives

The draft FS evaluates 12 potential remedial alternatives, including a series of removal-focused ("r"-series) and integrated ("i"-series) alternatives that combine remedial technologies across the Site.

Any alternative selected by EPA for the Site must meet the threshold criteria of protecting human health and the environment and meeting applicable or relevant and appropriate requirements (ARARs) of federal and local laws.

In addition to the threshold criteria, EPA regulation and guidance requires the selected alternative to provide the best balance with respect to other Superfund remedy selection criteria under which the following are considered in the draft FS:

- provide long-term effectiveness
- reduce short-term environmental impacts to the river, community, workers and the environment
- take advantage of the natural recovery process
- provide permanence
- allow flexible sequencing of cleanup actions and further refinement during remedial design
- balance effectiveness and costs

Ultimately, comparing and contrasting the costs and benefits of the various alternatives is part of EPA's risk management decision-making framework for selecting the cleanup remedy. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (EPA 2005).

The scoring of the alternatives in the draft FS is based on the extensive amount of data collected and analyzed over the past decade, as well as sophisticated computer modeling that provides an effective tool for evaluating the relative performance of the comprehensive alternatives.

Figure 2 Draft Summary of Comparative Analysis of Remedial Alternatives

Alternative	Threshold Criteria		Balancing Criteria						
			Effectiveness Criteria			Implementability	Summary Score Balancing Criteria	Cost ($M)	
	Overall Protection	Meets ARARs	Long-term Effectiveness	Reduction of Toxicity through Treatment	Short-term Effectiveness			Low[3]	High[3]
A - No Action	No[1]	No	○	○	◑	◑	NA	$ -	$ -
B-i	Yes	Yes[2]	◕	◔	●	●	●	$169	$250
B-r	Yes	Yes[2]	◕	○	◑	●	◕	$228	$330
C-i	Yes	Yes[2]	●	◔	●	●	●	$231	$345
C-r	Yes	Yes[2]	◕	○	◑	◕	◑	$304	$449
D-i	Yes	Yes[2]	●	◔	●	◕	●	$266	$398
D-r	Yes	Yes[2]	◕	○	◑	◑	◑	$351	$520
E-i	Yes	Yes[2]	◕	◑	◑	◕	◕	$463	$709
E-r	Yes	Yes[2]	◕	○	◔	◑	◔	$568	$884
F-i	Yes	Yes[2]	◕	◑	◔	◑	◑	$878	$1,389
F-r	Yes	Yes[2]	◕	○	○	○	○	$1,077	$1,762

1 - Alternative A - No Action is protective for some portions of the Site.

2 - With respect to surface water ARARs, EPA will determine whether the alternatives meet those ARARs with respect to contamination that will remain on Site or whether waivers of certain surface water ARARs are appropriate due to background and other issues. As discussed in Section 9 of the draft FS, the alternatives do not differ with respect to long-term projected post-remedy surface water concentrations.

3 - The cost of the entire duration of the project in today's dollars.

NA - Not applicable. Alternative does not meet threshold criteria.

Legend:

○ The alternative scores very low for the criterion.
◔ The alternative scores low for the criterion.
◑ The alternative scores moderately for the criterion.
◕ The alternative scores high for the criterion.
● The alternative scores very high for the criterion.

Community Outreach

The LWG has worked with the community for many years during the development of the Remedial Investigation and the Feasibility Study. For more than a decade the Portland Harbor Community Advisory Group (CAG) has engaged with the LWG, EPA and its partners, offering valuable input to the process. The CAG provided substantive comments on issues related to early action project reviews, use of innovative technologies, dredge disposal options, future decisions about river cleanup sequencing and source control. Moreover, the CAG encouraged more clarity in the preparation and review of key documents; provided hands-on education to surrounding involved communities; and advised the LWG, EPA and its partners on community concerns.

Next Steps

The public will have opportunities to learn about the draft FS and understand what it means for the future of the cleanup of the Lower Willamette River. More information on public education opportunities can be found at www.lwgportlandharbor.org.

The Lower Willamette Group (LWG)

The Lower Willamette Group (LWG) is composed of the 10 parties who signed an agreement with EPA to conduct the Remedial Investigation and Feasibility Study (RI/FS) of the Site and four other parties who have contributed financially to the project. The LWG is a small subset of the potentially responsible parties (PRPs) identified by the U.S. Environmental Protection Agency (EPA).

The members of the LWG are: Arkema Inc.; Bayer CropScience, Inc.; BNSF Railway Company; Chevron U.S.A. Inc.; City of Portland; ConocoPhillips Company; Gunderson LLC; Kinder Morgan Liquids Terminals; NW Natural; EVRAZ; Port of Portland; Siltronic Corporation; TOC Holdings Co.; Union Pacific Railroad Company.

The LWG is performing the RI/FS for the Site pursuant to an EPA Administrative Settlement Agreement and Order on Consent for RI/FS (AOC; EPA 2001a, 2003a, 2006a). As provided in the Statement of Work (SOW) to the AOC, the objectives of the Portland Harbor FS are to:

- Develop and evaluate potential remedial alternatives to reduce risks to acceptable levels
- Support EPA's identification and selection of a preferred alternative

Oversight of the Portland Harbor Superfund

Oversight of the Portland Harbor Superfund Site
EPA has regulatory authority over the Superfund process and cleanup based on the 1980 **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)**. EPA is the lead agency on the investigation and cleanup of near shore and in-water sediments. In addition, EPA works together with other partners on the site:

- Oregon Department of Environmental Quality (lead agency for upland cleanups and source control)
- Oregon Department of Fish & Wildlife
- National Oceanic and Atmospheric Administration
- U.S. Fish and Wildlife Service
- Tribal Governments:
  - Confederated Tribes of the Warm Springs Reservation of Oregon
  - Confederated Tribes and Bands of the Yakama Nation
  - Confederated Tribes of the Grand Ronde Community of Oregon
  - Confederated Tribes of the Siletz Indians
  - Confederated Tribes of the Umatilla Indian Reservation
  - Nez Perce Tribe

Site Description and Summary of Potential Risk

Site Description

The Portland Harbor Superfund Site is an urban and industrial reach of the Lower Willamette River located immediately downstream of downtown Portland.

Portland Harbor is Oregon's largest seaport connecting a deep-water channel to a network of railways, roadways and pipelines. It is heavily industrialized and urbanized with numerous manufacturing, vessel building, petroleum storage and metals salvaging activities as well as municipal activities. The area has been extensively modified over the past 160 years by wetland draining and filling, channelizing and dredging of the river to accommodate a navigation channel for importing and exporting goods and services to the region and the state, and for supporting other maritime commercial activities.

The Willamette River is the 13th largest river in the contiguous United States, with substantial flows averaging 33,000 cubic feet per second. Much of the riverbank contains overwater piers and berths, terminals and slips, and other engineered features (e.g., armoring such as rip rap makes up approximately half of the harbor shoreline). These extensive physical alterations have resulted in a river reach that bears little resemblance to its pre-industrialized, pre-urbanized character in terms of hydrodynamics, sediment processes, ecological habitat and human uses.

Approximately 60 percent of the riverbed coincides with the federal navigation channel. The near shore areas between the riverbank and the channel edge are often artificially narrow and steep-sloped along much of the main stem of the river. Nearly 90 percent of the river in Portland

Harbor is depositional or has no substantial change meaning more sediment comes into the Lower Willamette River from upstream than leaves the river into the Columbia River and Multnomah Channel.

Remedial Investigation Summary

The draft Remedial Investigation (RI), including the human health and ecological risk assessments, was completed and submitted to EPA in 2009, and then revised and resubmitted in 2011. The RI is anticipated to be finalized prior to EPA issuing the Proposed Plan. The draft FS incorporates the conclusions of the draft RI report, and EPA has approved the draft FS data set.

The Draft FS incorporates many years of scientific investigation and analysis. It describes the nature and extent of contamination; characterizes physical conditions and the potential movement of contaminants; and assesses the potential risks that contamination may pose to human health, fish and wildlife.

Key findings of the RI include the following:

Extent of Contamination

- Higher concentrations of chemical contaminants in sediments generally occur near shore and in areas such as current or historical docking areas (i.e. slips) and lagoons.
- Chemical concentrations are generally higher in deeper sediments than in the surface layer. This indicates that past chemical inputs were greater than current inputs and that surface sediment quality has improved over time. Based on the data, it appears most of the sediment contamination is from historic practices. The few exceptions include areas where higher surface sediment concentrations appear to be associated with ongoing local sources, low rates of sediment deposition, or physical disturbance of surface sediments.
- Chemical concentrations in surface sediments within the navigation channel and in areas away from likely sources are relatively lower similar to levels measured in sediments upriver of the Site in areas unaffected by Portland Harbor sources.
- Sediments immediately downstream of the Study Area, in either the Willamette River main stem or Multnomah Channel, show little evidence of chemical migration from the Study Area.

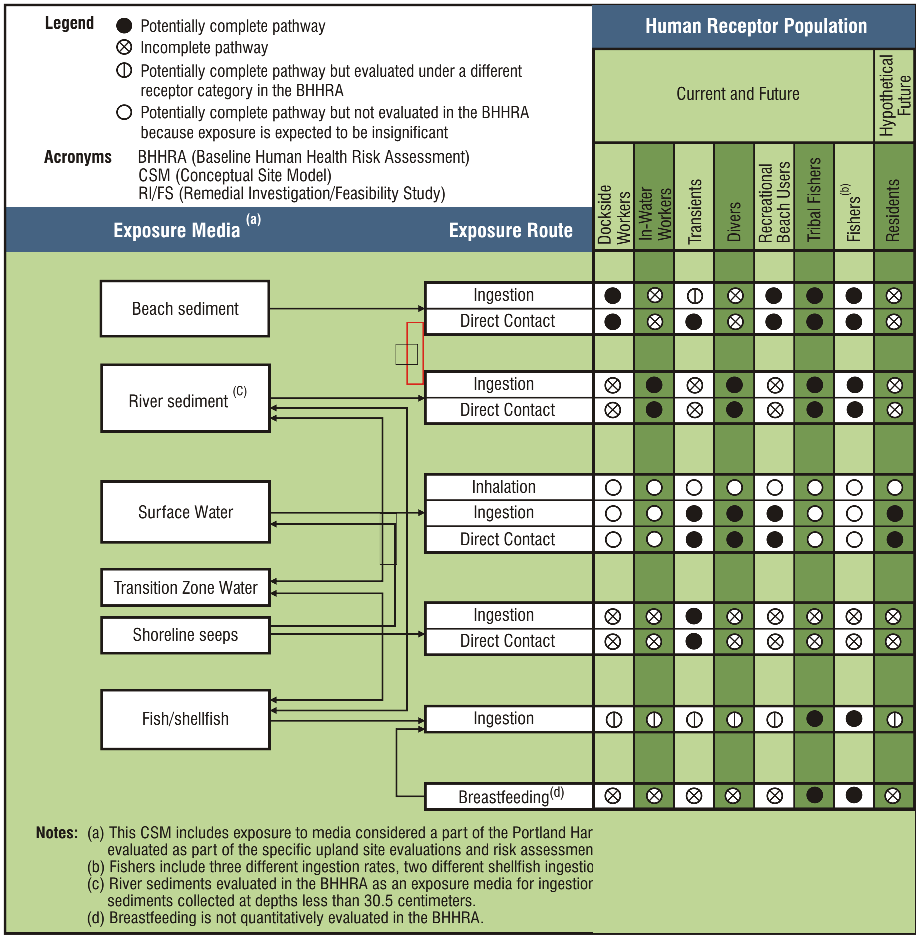
Sources and Pathways of Contamination

- Most of the sediment contamination in the Study Area is associated with known or suspected historical sources and practices that have largely been discontinued or otherwise controlled. Industrial activities along the harbor included ship building, dismantling, and repair; gas and chemical manufacturing; steel production; wood treatment operations; metal recycling; fuel storage and transfer operations; electrical production and distribution; and rail yards. Other potential sources along the harbor included ship terminals, roads, numerous wastewater and stormwater outfalls and runoff, and overwater discharges. Agricultural activities, while present within the harbor in the early part of the last century, now occur primarily upriver.
- Public and private outfalls located on both banks of the river discharge stormwater. There are substantial agricultural, industrial and municipal activities upstream of the harbor. Private and public parties along the river obtain permits that regulate the proper use, storage and discharge of chemicals. Control of upland and upstream sources is outside the scope of the draft FS.
- Chemicals still reach the Site through various pathways, including municipal and industrial stormwater outfalls, industrial discharges, overland transport, atmospheric deposition, bank erosion, groundwater, and incidental releases within the Study Area, as well as in surface water and sediment inflows from upstream. Most of these sources and pathways are regulated by federal, state, and local governments.
- Upstream sources include or have included sewers, outfalls, stormwater runoff and direct discharge of industrial wastes; bank erosion, groundwater, and incidental releases to the river; agricultural runoff; and atmospheric deposition of global or regional contaminants into the watersheds that drain into the Willamette Valley.
- The greatest quantity of contaminants continuing to come into the Site are from upstream (i.e., Willamette River Watershed) rather than from within the Site.
- Contributions of contaminants to the Site via groundwater are currently limited to a few upland properties where source controls are being addressed.

Baseline Human Health Risk Assessment

The Baseline Human Health Risk Assessment (BHHRA) evaluated the potential for adverse human health effects from exposure to chemicals within the Study Area. The general objective of the BHHRA was to assess the potentially unacceptable risks to human health from exposure to chemicals present in sediment, surface water and groundwater seeps, and consumption of fish and shellfish. The results of the BHHRA were used to refine remedial action objectives and to inform decisions about the proposed cleanup of the Site.

Figure 3 Human Health Risk Assessment Conceptual Site Model



Exposure Media	Exposure Route	Dockside Workers	In-Water Workers	Transients	Divers	Recreational Beach Users	Tribal Fishers	Fishers [b]	Residents
Beach sediment	Ingestion	●	⊗	⦶	⊗	●	●	●	⊗
	Direct Contact	●	⊗	●	⊗	●	●	●	⊗
River sediment	Ingestion	⊗	●	⊗	●	⊗	●	●	⊗
	Direct Contact	⊗	●	⊗	●	⊗	●	●	⊗
Surface Water	Inhalation	○	○	○	○	○	○	○	○
	Ingestion	○	○	●	●	●	○	○	●
	Direct Contact	○	○	●	●	●	○	○	●
Shoreline seeps	Ingestion	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗
	Direct Contact	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗
Fish/shellfish	Ingestion	⦶	⦶	⦶	⦶	⦶	●	●	⦶
	Breastfeeding[d]	⊗	⊗	⊗	⊗	⊗	●	●	⊗

Approach to the Baseline Human Health Risk Assessment

The BHHRA evaluated the following exposure scenarios and receptors:

- **Dockside worker** — direct exposure to (i.e., ingestion of and skin contact with) beach sediment.
- **In-water worker** — direct exposure to in-water sediment.
- **Transient** — direct exposure to beach sediment, surface water, and groundwater seeps.
- **Adult and child recreational beach user** — direct exposure to beach sediment and surface water.
- **Tribal fisher** — direct exposure to beach sediment or in-water sediment, and fish consumption.
- **Fisher** — direct exposure to beach sediment or in-water sediment, fish consumption, and shellfish consumption.
- **Diver** — direct exposure to in-water sediment and surface water.
- **Domestic water user** — direct exposure to untreated surface water hypothetically used as drinking water source in the future.
- Infant consumption of human milk was included as a complete exposure pathway for all adult receptor populations that were assessed quantitatively for bioaccumulative contaminants.

The BHHRA incorporated health-protective assumptions for developing exposure scenarios, the estimates of exposure, and the use of toxicity values based on discussions with and direction from the EPA and its partners. Per EPA guidance, using conservative exposure scenarios and toxicity values may overestimate risks, and this potential overestimation may be considered by EPA when making decisions about Site cleanup.

The BHHRA evaluated both non-cancer and cancer effects. The potential for non-cancer effects compares the estimated exposures to their toxicity values, the threshold for adverse effects using a ratio approach (i.e., Hazard Quotient [HQ] for single chemicals or Hazard Index [HI] for a chemical mixture where HI is the sum of HQs for chemicals in the mixture). When the HQ or HI is below one, no hazard is expected. When the HQ or HI is equal to or above one, a potential health hazard may be present. The EPA and DEQ acceptable level for non-carcinogens is an HQ or HI of one.

The potential for cancer was evaluated by comparing the estimated increase in probability of cancer during an individual's lifetime associated with Site-related exposure to a target risk range, which is the “target range” for EPA risk management as a part of the Superfund program. The DEQ acceptable risk levels are one in a million for individual carcinogens and one in one-hundred thousand or cumulative cancer risk.

Figure 4 Two Examples of Human Health Risk Assessment Receptor Exposure Assumptions

	Fisher		Beach User	
	Fish	**Sediment**	**Sediment**	**Water**
Intake Rate	19 meals per month 10 meals per month 2 meals per month	Face, hands, forearms and lower legs (beach) Hands and forearms (in-water) Soil ingestion rates	Face, hands, forearms and lower legs (beach) Soil ingestion rates	Entire body Approx. 2 ounces per hour ingested
Exposure Duration and Frequency	365 days per year 30 years	2 or 3 days per week 30 years	5 days per week in summer, 1 day per week in spring/fall, 1 day per month in winter 30 years (adult) 6 years (child)	2 days per week in summer (adult) 5 days per week in summer (child) 30 years (adult) 6 years (child)
Uncertainties	Preparation methods Species consumed Site use Toxicity values	Beach use Site use Amount of contact Sediment adherence Toxicity values	Beach use Site use Amount of contact Sediment adherence Toxicity values	Swimming frequency Dermal absorption Toxicity values

Results of the Baseline Human Health Risk Assessment

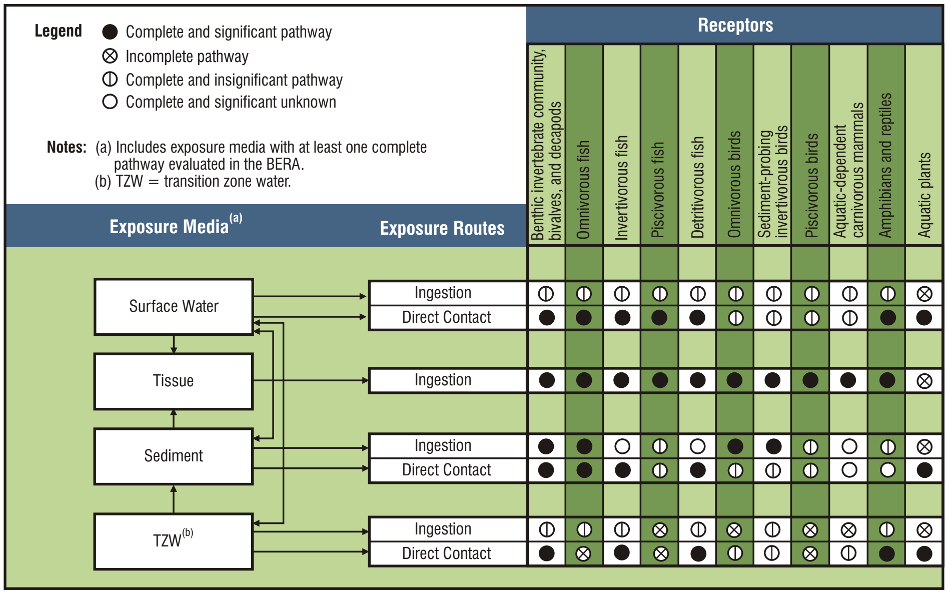
The major findings of the BHHRA include:

- Consumption of resident fish (e.g. smallmouth bass and carp), and in particular whole body consumption (including organs, eyes and skin), is the exposure scenario that presents the most potential risk. Potential risks from resident fish and shellfish consumption exceed the target HI of one and the target cancer risk range of one in a million to one in ten thousand. Consumption of migrating fish, like salmon, does not pose a similar risk.
- PCBs, and to a lesser extent dioxins/furans, PAHs, and DDx, account for almost all of the estimated human health risk. PCBs are the primary contributors to human health risk on a site-wide basis; with ingestion of resident fish (e.g., bass, carp) representing the primary exposure pathway and the highest estimated potentially unacceptable risk.
- Potential risks resulting from direct contact with sediment, surface water or seeps are much lower.
- All of the direct contact scenarios result in potential risks within or below the EPA target cancer risk range of one in a million to one in ten thousand (except for two ½- mile segments of the river for the Tribal fisher scenario and one location for the hypothetical use of untreated surface water as a drinking water source).
- The direct contact scenarios also result in non-cancer hazards below the target HI of 1, with the exception of one ½-river mile segment for in-water sediment and one location for hypothetical use of untreated surface water as a drinking water source.
- The impact of uncertainties associated with risk estimates for the resident fish and shellfish consumption scenarios were considered in the draft FS and should be taken into account for decisions about cleanup of the Site. Risk estimates in the BHHRA are based on multiple assumptions that typically overestimate the actual risks.

Baseline Ecological Risk Assessment (BERA)

The Baseline Ecological Risk Assessment (BERA) evaluated the potential for adverse effects on plants, invertebrates, amphibians, fish, and wildlife from hazardous chemicals within the Study Area. The primary objective of the BERA was to characterize the risks of chemical effects on these aquatic and aquatic-dependent ecological receptors in the Study Area.

Figure 5 Ecological Risk Assessment Conceptual Site Model



Approach to the Baseline Ecological Risk Assessment

Ecological receptors were chosen for the assessment based on criteria consistent with EPA guidance. The receptors selected for assessment were:

- **Benthic invertebrate community** — benthic macroinvertebrate community, which includes clams, amphipods, crayfish, midge larvae and oligochaetes worms
- **Omnivorous fish populations** — largescale sucker, carp, and pre-breeding white sturgeon
- **Invertivorous fish populations/individuals —** populations of sculpin and peamouth, and individual juvenile Chinook salmon
- **Piscivorous fish populations** — smallmouth bass and northern pikeminnow
- **Detritivorous fish individuals** — Pacific lamprey ammocoetes
- **Omnivorous bird populations** — hooded merganser
- **Sediment-probing invertivorous bird populations** — spotted sandpiper
- **Piscivorous bird populations/individuals** — osprey population and individual bald eagles
- **Aquatic-dependent carnivorous mammal populations** — river otter and mink
- **Amphibian and reptile populations** — amphibians (e.g., frog, salamander) and reptiles (turtle species)
- **Aquatic plant community** — phytoplankton, periphyton, macrophyte species

In general, the goal for assessing ecological receptors is to determine what is necessary to protect and maintain populations and the communities in which they live. However, in the case of special status species, such as those protected by federal or state regulations or otherwise deemed culturally significant, EPA sets a higher goal: survival, growth and reproduction of individual organisms.

In Portland Harbor, juvenile Chinook salmon, Pacific lamprey ammocoetes and bald eagle were identified as special status species. For practical reasons and to be conservative, the organism-level measurement endpoints (survival, growth and reproduction) were used for all receptors, requiring extrapolation to assess potential risks to populations and communities.

The BERA identified contaminants that pose potentially unacceptable ecological risk. Risk estimates are stated as hazard quotients (HQs), which are calculated as the estimated exposure point concentration divided by the concentration that defines a threshold for adverse effects, typically a toxicity reference value (TRV). A HQ greater than one in the final step of the risk characterization represents potentially unacceptable risk.

Results of the Baseline Ecological Risk Assessment

The BERA identified 89 contaminants (as individual chemicals, sums or totals) that pose potentially unacceptable risk. The likelihood and ecological significance of the potentially unacceptable risk varies across contaminants and lines of evidence (LOEs) from very low to high. The findings of the BERA are:

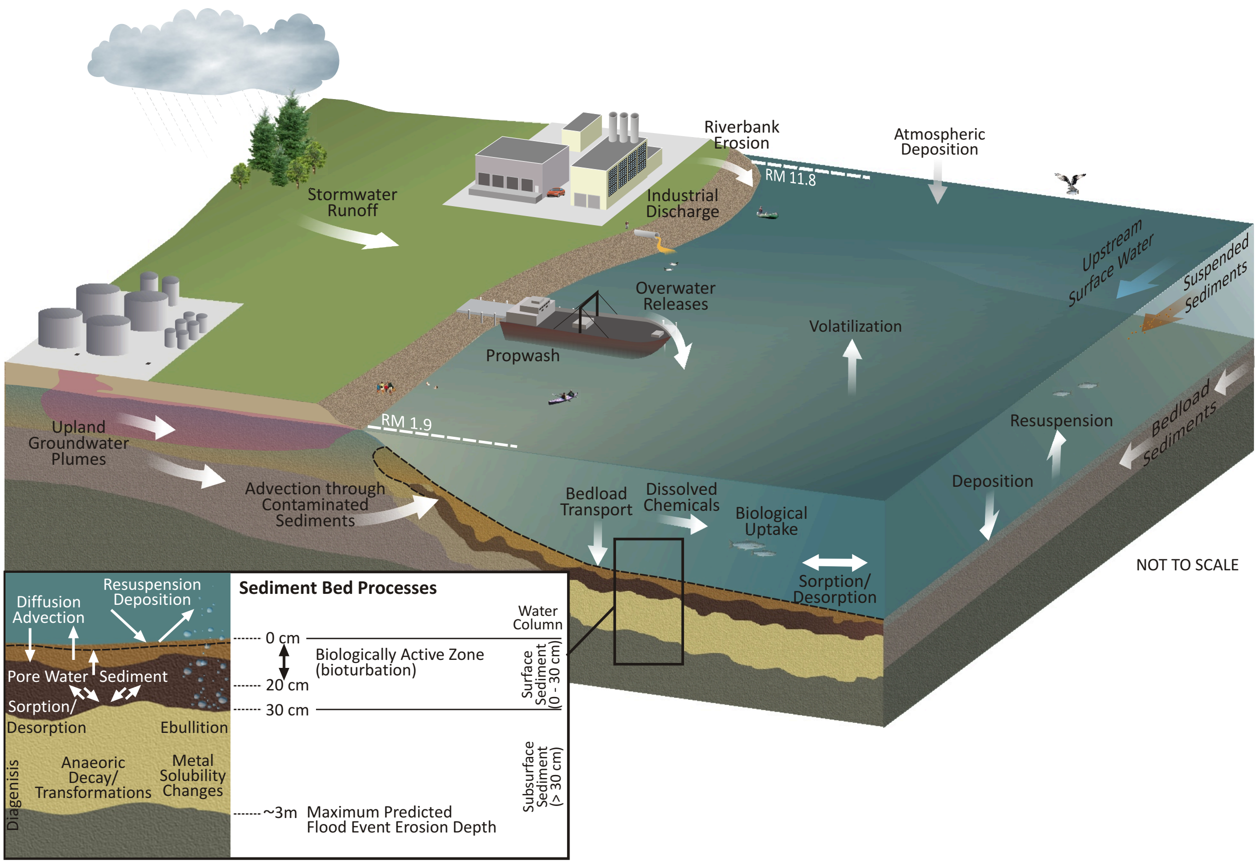
- Total PCBs are the primary risk contributor to mink, river otter, and spotted sandpiper, and pose low risk to osprey, bald eagle, sculpin, and smallmouth bass. Primary also DDT and its breakdown products (referred to as total DDx) (DDT and related breakdown products). Total toxic equivalent (TEQ), which incorporates both PCB and dioxin and furan exposure, was also found to be a primary risk contributor to mink and river otter and to pose low risk to spotted sandpiper, osprey and bald eagle.
- Total DDx was found to generally pose negligible risk to bald eagle and Pacific lamprey ammocoetes and negligible to potential low risk within limited portions of the Study Area. DDx risk to sculpin and spotted sandpiper populations was assessed to be negligible based on the weight of evidence.
- Zinc, benzo(a)anthracene, benzo(a)pyrene, naphthalene and DDx were found to pose potential localized risk to individual Pacific lamprey ammocoetes due to possible exposure to contaminated shallow transition zone water in localized areas.
- Contaminants occur at concentrations that are projected to pose potentially unacceptable risk to the benthic community for about 7 percent of the Site. Unlike other ecological receptors, for which risk was evaluated on a chemical-specific basis, potential risk to the benthic invertebrate community was evaluated in large part by considering exposure to a mixture of chemicals present in the Site sediments.

Conceptual Site Model

The draft FS Conceptual Site Model (CSM) was developed to synthesize the information important to the draft FS evaluation, which was gathered through the physical, chemical and biological characterization of the Site during the RI. The CSM provides a coherent picture of current Site conditions, including the important processes affecting contaminants at the Site, potential risks posed, and currently known sources.

These key building blocks the RI and CMS form the foundation of the detailed alternative analysis of the draft FS.

Figure 6 Draft FS Conceptual Site Model



Cleanup Objectives and Goals

The Superfund process is designed to reduce risks to human health and the environment to acceptable levels. The process of establishing the cleanup objectives and goals for sediment sites necessary to achieve sufficient risk reduction is complex. EPA will likely incorporate the following to establish final cleanup levels in the Proposed Plan and Record of Decision:

- EPA Risk Management Principles
- Remedial action objectives
- Preliminary remedial goals and remedial goals
- Remediation action levels
- EPA's final cleanup levels

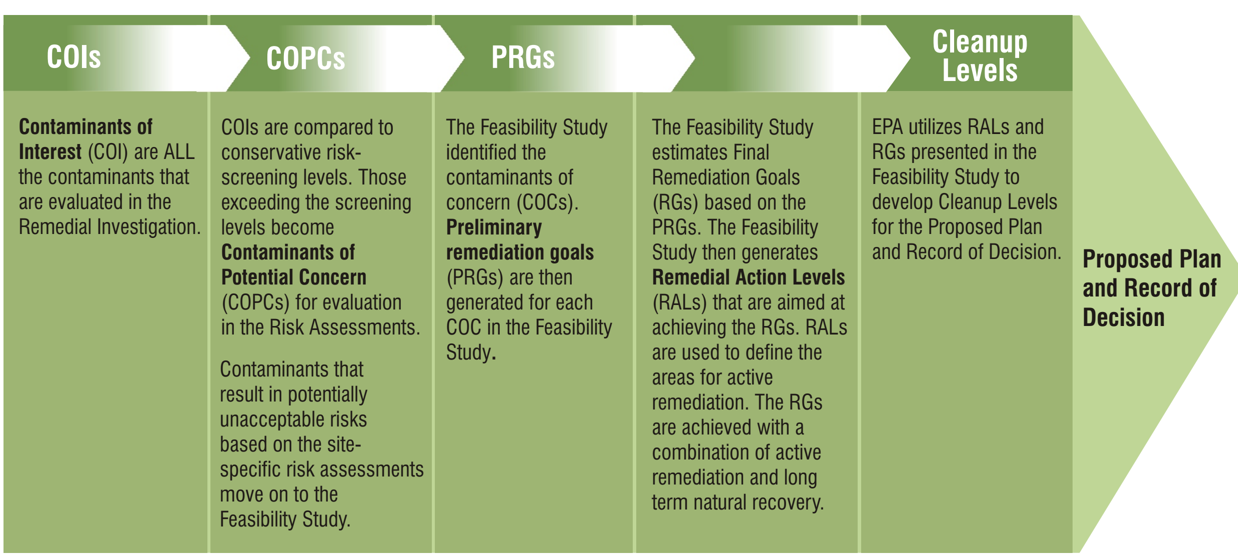
EPA Risk Management Principles

The process for determining how to reduce risks at contaminated sediment sites is guided by a set of general risk management principles established by EPA and recommended for use at large sediment Superfund sites. The draft FS has been developed consistent with those risk management principles outlined in EPA's risk management principles (US EPA 2002) and contaminated sediment remediation guidance (US EPA 2005).

EPA's 2002 and 2005 guidances provide principles to guide site managers in, *"making scientifically sound and nationally consistent risk management decisions at contaminated sediment sites."* These include:

1. Control sources early
2. Involve the community early and often
3. Coordinate with states, local governments, Indian tribes, and natural resource trustees
4. Develop and refine a conceptual site model (CSM) that considers sediment stability
5. Use an iterative approach in a risk-based framework
6. Carefully evaluate the assumptions and uncertainties associated with site characterization data and site models
7. Select site-specific, project-specific, and sediment-specific risk management approaches that will achieve risk-based goals
8. Ensure that sediment cleanup levels are clearly tied to risk management goals
9. Maximize the effectiveness of institutional controls and recognize their limitations
10. Design remedies to minimize short-term risks while achieving long-term protection
11. Monitor during and after sediment remediation to assess and document remedy effectiveness
12. Focus on risk reduction, not simply on contaminant mass removal
13. Incorporate a realistic, site-specific evaluation of the potential effectiveness of each remedial technology
14. Evaluate the comparative net risk reduction potential of the comprehensive alternatives, including a realistic evaluation of their respective advantages and site-specific limitations and the risks introduced by implementing the alternatives
15. Consider the use of combinations of remedies is appropriate
16. Compare and contrast the costs and benefits of the various sediment remedies as part of the risk management decision-making framework

Figure 7 Portland Harbor Superfund Site:
How Contaminant Cleanup Levels Are Established



Remedial Action Objectives

For the Portland Harbor Superfund Site, EPA established a specific set of remedial action objectives (RAOs) based on the human and ecological risk assessments. The RAOs are the narrative objectives that indicate what sediment cleanup remedies should accomplish to reduce human health and ecological risks.

Remedial Action Objectives

Human Health

RAO 1—Sediments: Reduce to acceptable levels human health risks from exposure to contaminated sediments resulting from incidental ingestion of and dermal contact with sediments, and comply with identified ARARs.

RAO 2—Biota Ingestion: Reduce to acceptable levels human health risks from indirect exposures to COCs through ingestion of fish and shellfish that occur via bioaccumulation pathways from sediment and/or surface water, and comply with identified ARARs.

RAO 3—Surface Water: Reduce risks from COCs in surface water at the Site to acceptable exposure levels that are protective of human health risks from ingestion of, inhalation of, and dermal contact with surface water; protect drinking water as a future beneficial use of the Willamette River at the Site; and comply with identified ARARs.

RAO 4—Groundwater: Reduce to acceptable levels human health risks resulting from direct exposure to contaminated groundwater and indirect exposure to contaminated groundwater through fish and shellfish consumption, and comply with identified ARARs.

Ecological

RAO 5—Sediments: Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated sediments, and comply with identified ARARs.

RAO 6—Biota (Prey) Ingestion: Reduce to acceptable levels risks to ecological receptors from indirect exposures through ingestion of prey to COCs in sediments via bioaccumulation pathways from sediment and/or surface water, and comply with identified ARARs.

RAO 7— Surface Water: Reduce risks from COCs in surface water at the Site to acceptable exposure levels that are protective of ecological receptors based on the ingestion of and direct contact with surface water, and comply with identified ARARs.

RAO 8—Groundwater: Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated groundwater and indirect exposures through ingestion of prey via bioaccumulation pathways from groundwater, and comply with identified ARARs

Preliminary Remedial Goals and Remedial Goals

The preliminary remedial goals (PRGs) and proposed remedial goals (RGs) are numeric concentrations of contaminants intended to meet the RAOs and used to assist in evaluating the remediation alternatives.

The proposed RGs are used to present the RAOs, help define alternatives, and assist the effectiveness evaluation of each alternative. The proposed sediment RGs in the draft FS identify the COC, the associated risk exposure scenario (either human health or ecological), the concentration, and the relevant exposure area.

RGs are specific, desired long-term endpoint concentrations for different exposure pathways over various exposure areas that are estimated to protect human health and ecological receptors.

EPA sediment remediation guidance advocates understanding the “sensitivity” of RGs to various assumptions and calculations. A sensitivity analysis was therefore undertaken to develop a range of sediment RG values from the initial single point concentrations.

The sensitivity analysis focused on two select COCs PCBs and BaPEq (a measure of PAHs) and the potential comprehensive benthic risk areas. These were selected because they are widely distributed across the Site.

The findings of this sensitivity analysis inform the evaluation of draft FS alternatives by providing a range of sediment RG values for different COC-receptor pairs that likely would satisfy the (NCP) protectiveness criterion.

The range of sediment RGs also are used to demonstrate how protective sediment remediation work would beat various points in time.

Remedial Action Levels

Remedial action levels (RALs) are chemical specific sediment concentrations in sediment that establish the sediment areas and volumes for active remediation in the draft FS. RALs are set at concentrations higher than RGs to achieve specific concentrations immediately after active remedy construction is completed.

RGs are achieved over longer periods of time for relevant exposure areas through active remedies in locations above the RALs and Monitored Natural Recovery (MNR) processes.

The LWG and EPA developed a specific set of RALs for each remedial alternative. The RALs were established for the bounding COCs PCBs, BaPEq, DDT (and its breakdown products DDE and DDD), dixons/furans, and potential comprehensive benthic risk areas. These RALs are used to delineate SMAs that also include other contaminants potentially posing unacceptable risks (i.e., the list of COC-specific RALs act as “bounding concentrations” for other contaminants).

Surface-area Weighted Average Concentrations (SWACs): The draft FS often refers to “SWACs.” In general, a SWAC is the average concentration of contamination in the upper one-foot of sediment over a particular area (e.g., per river mile). For example, for some exposure scenarios the average concentration (SWAC) is calculated over one river mile (e.g. smallmouth bass have a small home range so the exposure scenario for human consumption of smallmouth bass is one mile), while for other scenarios it may be the entire stretch of river (e.g., mink using the entire river to fish).

Figure 8 Summary of Sediment Remedial Action Levels for the Portland Harbor Site

Alternative	Description	Portland Harbor RALs (parts per billion)						
		PCB	PAH	DDD	DDE	DDT	Dioxin/ Furans	Benthic Toxicity
A	No further action.	None	None	None	None	None	None	None
B-Integrated	In-place technologies above RAL where implementable, otherwise removal	1,000	20,000	NA	1,000	NA	NA	No Toxicity in 10 Years
B-Removal	Removal above the RAL where implementable, otherwise in-place technologies	1,000	20,000	NA	1,000	NA	NA	No Toxicity in 10 Years
C-Integrated	In-place technologies above RAL where implementable, otherwise removal	750	15,000	NA	1,000	NA	NA	No Toxicity at Year Zero*
C-Removal	Removal above the RAL where implementable, otherwise in-place technologies	750	15,000	NA	1,000	NA	NA	No Toxicity at Year Zero*
D-Integrated	In-place technologies above RAL where implementable, otherwise removal	500	8,000	NA	200	NA	NA	No Toxicity at Year Zero*
D-Removal	Removal above the RAL where implementable, otherwise in-place technologies	500	8,000	NA	200	NA	NA	No Toxicity at Year Zero*
E-Integrated	In-place technologies above RAL where implementable, otherwise removal	200	4,000	100	50	150	0.02	No Toxicity at Year Zero*
E-Removal	Removal above the RAL where implementable, otherwise in-place technologies	200	4,000	100	50	150	0.02	No Toxicity at Year Zero*
F-Integrated	In-place technologies above RAL where implementable, otherwise removal	75	1,500	50	20	60	0.01	No Toxicity at Year Zero*
F-Removal	Removal above the RAL where implementable, otherwise in-place technologies	75	1,500	50	20	60	0.01	No Toxicity at Year Zero*
G	A variety of potential technologies	50	600	15	10	20	0.005	No Toxicity at Year Zero*

* No toxicity immediately after active remedy completion.

Final Cleanup Levels

The proposed sediment RGs and RALs are utilized in the draft FS to assist in the development and analysis of remedial alternatives. The final RGs and RALs will be selected in the Record of Decision. EPA will use the information from the FS to develop a Proposed Plan, which identifies EPA's recommended remedy for the Site and sediment cleanup levels. Based on the community and state comments on the Proposed Plan, EPA will develop a Record of Decision (ROD), which will contain the final cleanup levels for the Site.

Physical and Chemical Modeling

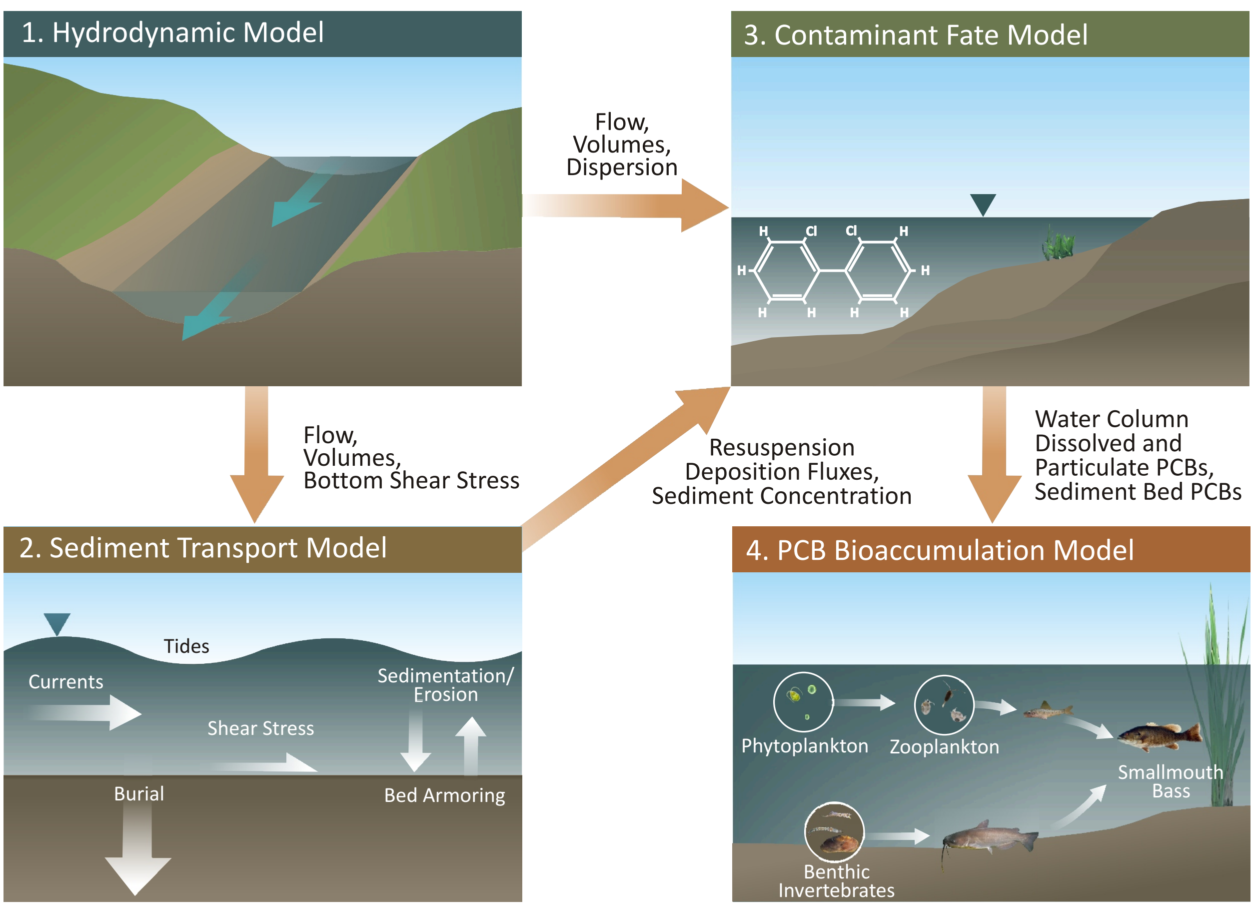
To support the evaluation of remedial alternatives conducted in the draft FS, a sophisticated suite of computer models was developed. Models such as these have been used for selecting remedies at other large, complex contaminated sediment sites. EPA has reviewed and approved the integrated model for use in the draft FS.

These models predict contaminant levels in water, sediment and fish tissue under current conditions and, more importantly, they project how the levels will change in the future as a result of natural recovery processes and remediation activities, such as capping and dredging.

The integrated model used for this draft FS contains four components that are linked together:

1. A hydrodynamic model that simulates changes in depth and movement of water due to currents and tides..
2. A sediment transport model that simulates how particles move with flowing water and how they accumulate or are scoured away from specific areas of the river bottom. These processes are referred to as deposition and erosion, respectively.
3. A contaminant fate model that predicts movement of contaminants with the water and the sediment particles, including transfers of contaminants between the water and the river bottom (i.e., sediment bed).
4. A food web model that predicts the amounts of contaminant that will accumulate and transfer through the food web as a result of the levels of specific contaminants in water and sediment. The food web includes invertebrates, which are eaten by small "forage" fish, which are in turn eaten by larger fish that could be eaten by humans.

Figure 9 Draft FS Model



All models contain uncertainty because they are simplifications of complex natural processes, and because there is variability in the information used to develop them. However, the draft FS took into account uncertainty in future model simulations as part of the comparative evaluation of the remedial alternatives.

The integrated model used in the draft FS is state-of-the-science, reflecting decades of field and laboratory studies conducted to understand the behavior and movement of sediments and contaminants in river environments. The model developed for the draft FS incorporates a wide body of Site-specific data collected during the Portland Harbor Remedial Investigation, including:

- Hydrodynamics: measurements of river flows and tides, current velocity measurements, detailed mapping of water depth (bathymetry) throughout the Site.
- Sediment transport: measurements of sediment type at approximately 1,700 locations across the Site; laboratory flume studies to measure the erosion potential of Portland Harbor sediments; detailed mapping of changes in bathymetry over time, which measures deposition and erosion; and measurements of the amount of sediment suspended in the water.
- Contaminant fate: measurements of contaminant concentrations at more than 2,200 locations across the Site, measurements of contaminant levels in water at numerous locations within the Site and under varying flow conditions, measurements of the amount of contaminants coming into the Site from areas upstream, measurements of contaminants leaving the Site (i.e., with downstream flows), measurements of contaminants flowing into the Site via stormwater, and in certain areas, the amount flowing into the Site via groundwater.
- Food web: measurement of contaminant levels in several different species of invertebrates (e.g., clams, worms, crayfish), small fish (e.g., sculpin), and larger fish (e.g., smallmouth bass, common carp, northern pikeminnow) at several locations across the Site.

Using existing data, the models were calibrated to Site conditions and were shown to reliably replicate characteristics of the Site, such as: sediment deposition and erosion patterns; concentrations of contaminants within the water, both in near shore areas and in the deeper navigational channel; concentrations of contaminants in surface sediment, including observed changes in concentration over time; and concentrations of contaminants in fish, including differences between species and between locations within the Site.

The model was used to project future contaminant levels under each of the draft FS alternatives to support the evaluations conducted in the draft FS. Model simulations over a 45-year period that included a hypothetical major flood event were performed for these evaluations. These model simulations projected future contaminant levels in water, sediment and fish throughout the Site. The draft FS used these projected contaminant levels to compare the long-term and short-term effectiveness of the remedial alternatives in reducing potential contaminant risks at the Site. The study used these model simulations, in conjunction with several empirical datasets, to evaluate the effectiveness of remediation alternatives by simulating the effects of technologies, such as capping and dredging, on contaminated sediments. The model took into account some of the limitations associated with these technologies (such as releases of contaminants to the water during dredging) and the pace of natural recovery (deposition of incoming clean sediments over contaminated sediments).

Sediment Management Areas (SMAs)

Based on the LWG's 2007 Round 2 Report, which data is part of the draft RI, EPA identified a broad areal extent of potentially unacceptable contaminant levels in 29 Areas of Potential Concern (AOPC) 28 discrete areas and one for the remainder of the Site. These AOPCs represent a general indicator of the areas of interest for the draft FS.

The draft FS starts with the AOPCs, and refines them into SMAs based on RALs applied to both surface sediments and buried contaminated sediments. The draft FS also considers additional factors that influence the size and shape of SMAs, such as potential risk, appropriate mapping of potential risk, and engineering considerations related to designing and conducting sediment remediation. This transition from AOPCs to SMAs reflects the RI/FS iterative process as outlined in Superfund guidance.

For the draft FS, the SMAs:

- Organize large sites into manageable areas and volumes that can be evaluated and cleaned up individually.
- Examine the area and depth of contamination to determine volumes of sediment requiring remediation based on the RALs associated with each alternative. Define areas where active remediation (e.g., dredging, capping, and in situ treatment) and monitored natural recovery (MNR) can occur both inside and outside the SMAs.
- Consider factors such as water dependent uses, navigation requirements, current and future water/shoreline uses, habitat areas, potential habitat restoration areas, and currently known historical or ongoing sources.
- Address buried contamination above the RALs present at the Site (via in-place or removal technologies).
- By performing active remedies in SMAs, plus MNR, risks will be adequately reduced throughout the Site.

There are localized instances outside SMAs where MNR is not reasonably likely to occur due to uncertainty in recovery estimates, empirical data, or processes that are not quantified in the draft FS modeling. This issue was thoroughly evaluated in the draft FS and did not result in the identification of any new SMAs.

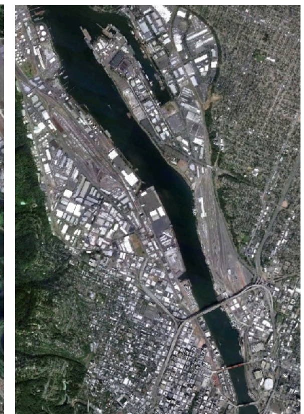
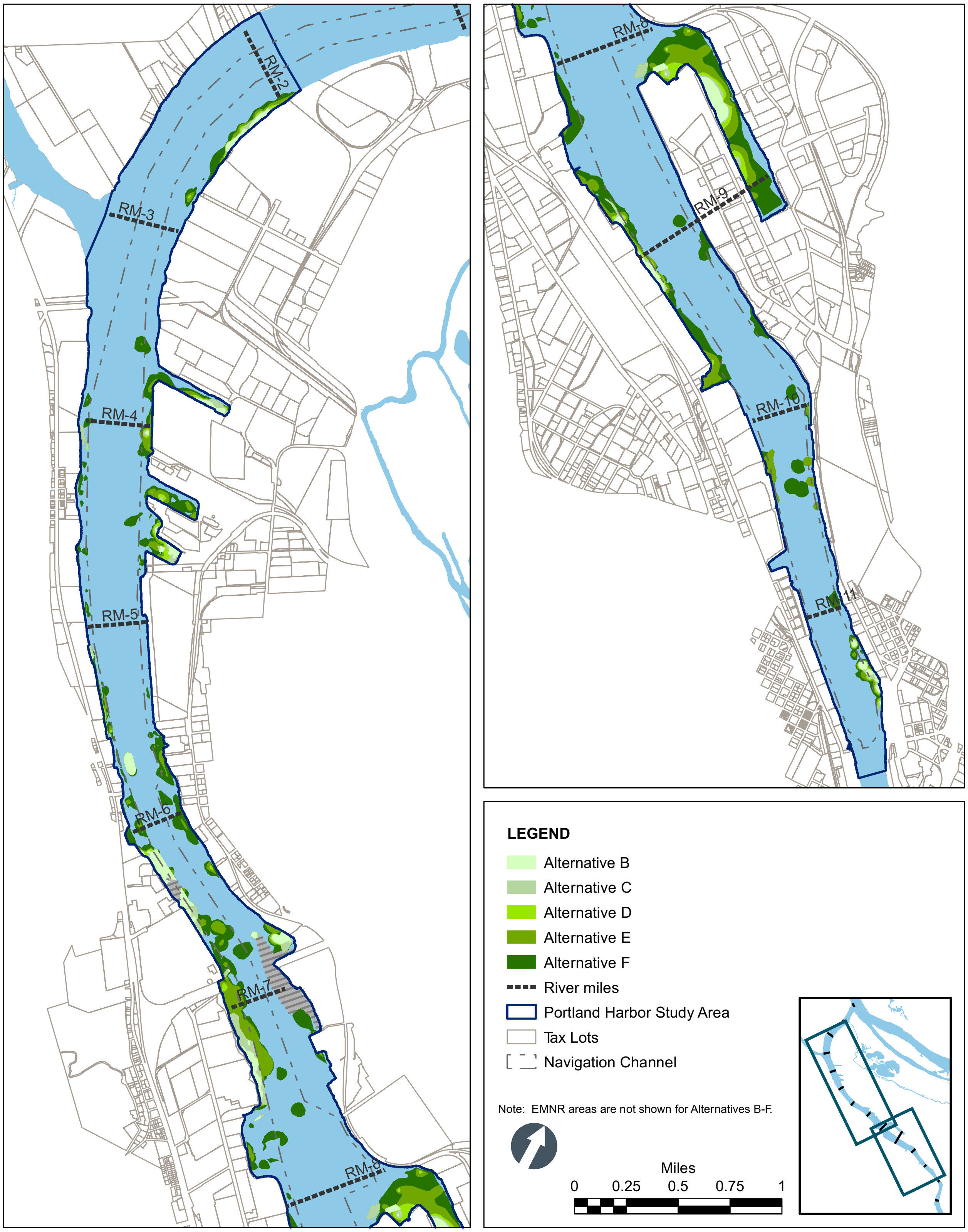


Figure 10 Sediment Management Areas



Cleanup Technologies

Multiple technologies can be used to approach sediment cleanup some methods use active remediation (dredging or capping technologies) and are typically combined with monitoring the river's natural ability to recover. All of the technologies assume that currently known contamination sources have been adequately controlled, both within and upstream of the Site, before sediment remediation commences. The following is a brief description of the technologies that were screened in the draft FS:

Innovative Technologies

Most methods of sediment cleanup described in the draft FS are tried and true and have been used in other complex river systems to lower potential risks to human and ecological health.

Innovative technologies that were evaluated in the draft FS include: in situ sediment treatment (e.g., placing activated carbon on the sediment surface); reactive caps (activated carbon or stabilization reagents); and ex situ dewatering/treatment (solidification treatment with pozzolanic materials [Portland cement] or stabilization reactive agents).

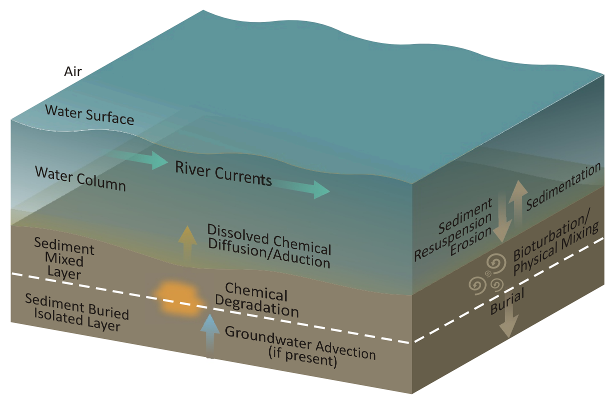
The screening of technologies conducted for the draft FS does not restrict further consideration or more detailed evaluations or applications of these technologies, as appropriate, either by EPA during Proposed Plan development or by EPA or individual parties during remedial design.

Technologies Evaluated in the Draft FS:

Institutional Controls (ICs) – Institutional controls generally refer to non-engineering measures guiding human activities to prevent or reduce exposure to hazardous substances. This often means limiting land or resource use, for example fish advisories.

Monitored Natural Recovery (MNR) – MNR is an integral component of the remedy at nearly every contaminated sediment site. It relies on ongoing, naturally occurring processes to contain or reduce contaminants bioavailability (i.e., ability to be taken up by organisms) or toxicity in sediment over time. Natural processes fundamental to the recovery of contaminated sediments include chemical transformation (e.g., breakdown of contaminants), changes in forms of contaminants that reduce mobility/bioavailability, physical isolation and dispersion. The most

Figure 11 Monitored Natural Recovery

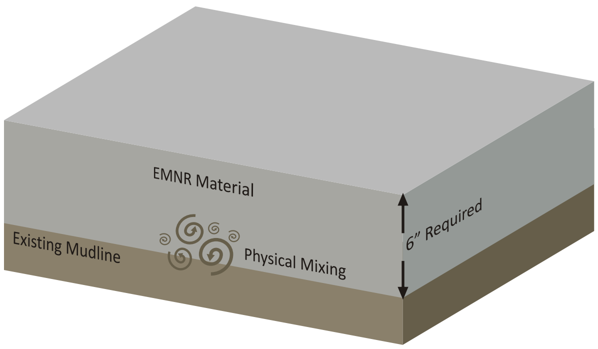


significant of these processes in Portland Harbor is physical isolation through natural sedimentation and eventual burial of contaminants, which the RI data shows has reduced concentrations of contaminants at the sediment surface of Portland Harbor over the past 20 years. MNR monitors the continued progress of these ongoing processes in reducing potential ecological and human health risks to acceptable levels to verify remedy success.

Enhanced Monitored Natural Recovery (EMNR) – EMNR enhances MNR sediment deposition through the application of a thin layer of suitable material, typically sand, to a sediment area targeted for remediation. Application thicknesses of approximately six inches are common, producing an immediate reduction in surface chemical concentrations.

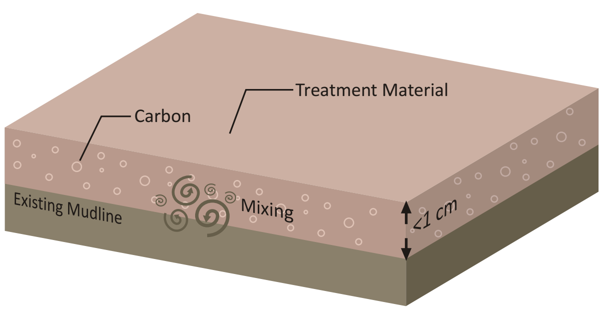
EMNR typically reduces the time to achieve RAOs (e.g., reduction in sediment contamination, reductions in potential risk from fish consumption) as compared to natural sedimentation alone.

Figure 12 In-place Technologies: Enhanced Monitored Natural Recovery



In Situ Treatment – in situ treatment is an innovative sediment remediation approach. It typically involves introducing sorbent amendments, such as activated carbon, into contaminated sediments to increase contaminant binding and reduce bioavailability. This process reduces uptake of contaminants by organisms, and therefore reduces potential exposure risks to people and the environment.

Figure 13 In-place Technologies: In-Situ Treatment

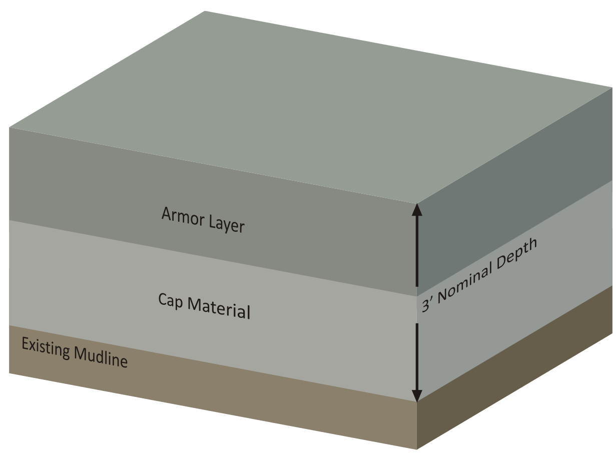


In situ treatment, particularly using direct amendment of the surface sediments with activated carbon, has recently proven effective in reducing the bioavailability of a range of sediment contaminants.

Capping – Capping is the placement of suitable material over contaminated sediment to isolate contaminants in place. Caps are generally constructed of granular material, such as suitable sediment, sand or gravel, but can have more complex designs.

Caps are designed to reduce potential risk through: 1) physical isolation of the contaminated sediment to reduce exposure through direct contact and to reduce the ability of burrowing organisms to move contaminants to the surface; 2) stabilization of contaminated sediment and erosion protection of sediment and cap to reduce resuspension and transport; or 3) chemical isolation of contaminated sediment to reduce exposure from contaminants transported into the water column.

Figure 14 In-place Technologies: Typical Cap



Caps may be designed with different layers to serve these primary functions or, in some cases, a single layer may serve multiple functions. Recent innovations have added new products to the standard capping material to assist treatment.

Removal – Removal of sediments can be accomplished either while sediments are submerged (dredging) or after water has been diverted or drained (excavation). Both methods require transporting the sediment elsewhere for treatment and/or disposal. To avoid potential adverse impacts to threatened fish and their critical habitat, removal would occur only during four months of each year (July to October).

Figure 15 Removal Technologies: Hydraulic Dredge

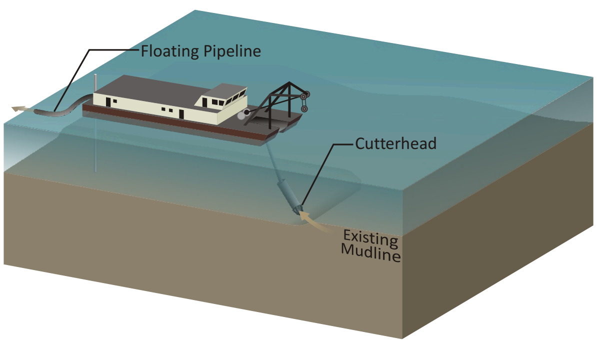
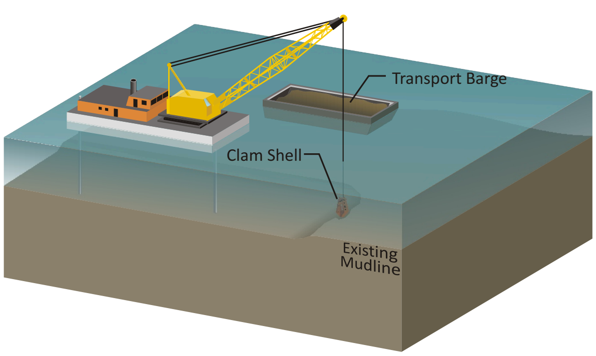
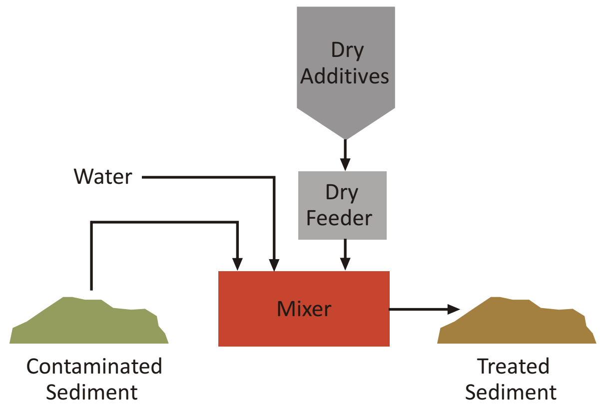


Figure 16 Removal Technologies: Mechanical Dredge



Ex Situ Treatment – Ex situ treatment requires removal before treatment can occur and disposal or use of the treated materials afterward. Treatment is defined as any process, applied or naturally occurring, that destroys or reduces toxicity, mobility or volume of contamination in the sediment once removed from the river.

Figure 17 Post-removal Technologies



Disposal–Disposal is the final component of the ex situ sediment remediation process that starts with removal and ends with placement (disposal) in a final location where environmental impacts can be controlled and limited. This process can also include ex situ treatment between removal and disposal to improve handling and shipping or reduce toxicity. Disposal can be within an in-water disposal facility specifically engineered for the sediment remediation or within an upland landfill disposal facility, such as a commercial landfill. The draft FS evaluated 14 potential disposal options, including near shore upland, landfills, and confined in-water disposal sites.

Figures 14 through 19 represent generic examples to illustrate these concepts.

Figure 18 Post-Removal Technologies: Nearshore Confined Disposal

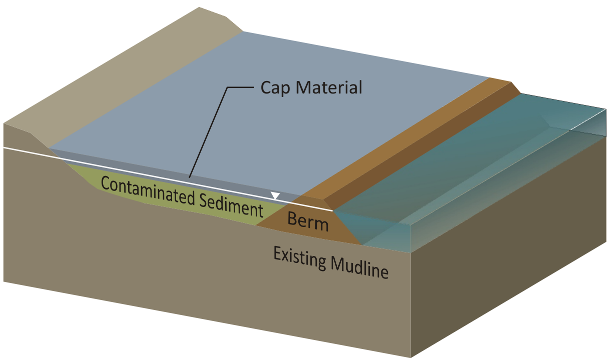


Figure 19 Post-Removal Technologies: Confined Aquatic Disposal

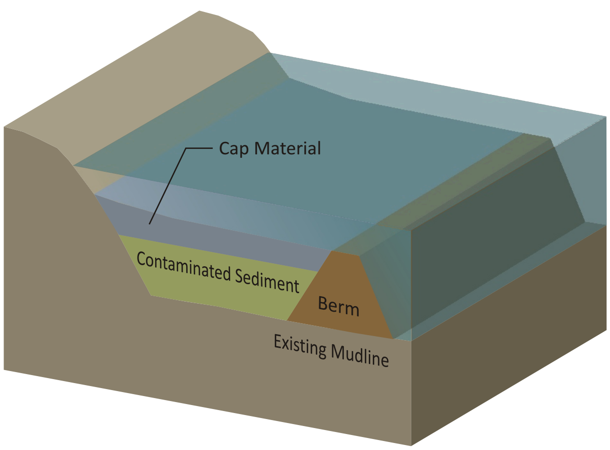
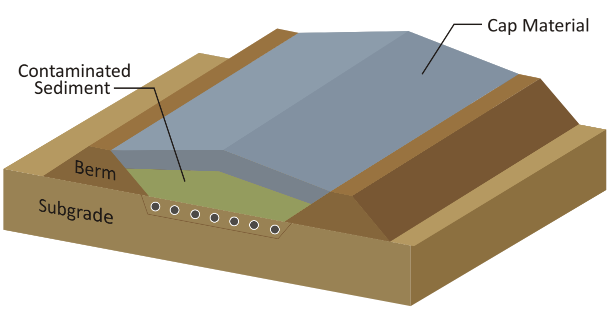


Figure 20 Post-Removal Technologies: Upland Confined Disposal



Results of the Draft FS Technology Screening:

The screening of technologies in the draft FS concludes that a considerable number of technologies and process options are likely effective and implementable across most of the SMAs at the Site, including institutional controls, MNR, EMNR, in situ treatment, capping, active capping, dredging/removal, ex situ stabilization treatment, and a large number of disposal options. These technologies were retained for the detailed evaluation of alternatives in the draft FS.

Figures 14 through 19 represent generic examples to illustrate these concepts.

Detailed Analysis, Comparison and Key Findings of Alternatives

Alternatives for site-wide cleanup were developed using technologies and remedial action levels (RALs). For the Portland Harbor draft FS, the alternatives were crafted using the full suite of technologies and EPA-approved alternative-specific RALs. The result is 11 alternatives everything from taking no action to large-scale dredging actions throughout the Site.

The draft FS also considered as part of the screening evaluation of alternatives an even larger-scale dredging action for the Site (Alternative G). Alternative G would involve active cleanup of 591 acres, take approximately 40 years to implement, and cost $1.88 billion. Alternative G would result in a significant increase in cost but no appreciable reduction in risk (compared to other alternatives). Therefore, the LWG did not carry G through the detailed analysis of alternatives.

The remaining alternatives (B, C, D, E and F) each involve two sub-options:

- “r” *removal-focused* – emphasizes dredging and disposal with limited capping, in situ treatment and monitored natural recovery;
- “i” *integrated* – using a combination of removal (dredging and disposal), capping, in situ treatment and monitored natural recovery.

Utilization of Remedial Action Levels (RALs)

Each of the alternatives contains remedial action levels (RALs) for the bounding COCs.

Each alternative assumes upland source control is effective and that natural recovery will be monitored over time to achieve the final remedial goals.

In most cases, cleanup activities to reduce potential risks from bounding COCs will also reduce potential risks from other co-located contaminants posing potentially unacceptable risk. For example, reducing potential risks from PCBs will also reduce potential risks from other contaminants found in the same location, which is a key finding from the Remedial Investigation and confirmed in the draft FS.

In general, the lower the RAL the larger the SMA footprint and the area to be actively remediated (e.g., the RALs for Alternative F are lower than the RALs for Alternative B and thus result in more acres of active sediment remediation under Alternative F).

Alternatives

"A" assumes there would be no active remediation of any sediment and relies only on natural recovery (without monitoring) to achieve remedial action objectives. This option is a baseline for comparison with the other remedial alternatives and is required by Superfund.
The other alternatives are compared in Figure 20.

Figure 21 Comparison of Alternatives

Alternative	Total Dredge Volume Removed	Dredge Areas	In-situ Treatment Areas	Engineered Cap Area	Use of CADs or CDFs[1]	Enhanced Monitored Natural Recovery	Years to Construct	Estimated Net Present Value Cost ($Millions)	
	(Cubic Yards)	(Acres)	(Acres)	(Acres)				Low[2]	High[2]
B-i	198,000 to 293,000	23	19	7	None	75	2	$169	$250
B-r	541,000 to 783,000	42	0	13	CAD &CDF	41	6	$228	$330
C-i	314,000 to 459,000	34	29	13	CAD & CDF	40	3	$231	$345
C-r	777,000 to 1,127,000	63	0	10	CDF	73	7	$304	$449
D-i	387,000 to 565,000	43	34	15	CAD & CDF	37	3	$266	$398
D-r	914,000 to 1,321,000	78	0	13	CDF	68	8	$351	$520
E-i	936,000 to 1,362,000	91	58	25	CDF	15	7	$463	$709
E-r	1,775,000 to 2,596,000	145	0	21	CDF	15	12	$568	$884
F-i	2,129,000 to 3,151,000	176	117	49	CDF	3	15	$878	$1,389
F-r	4,196,000 to 6,182,000	304	0	38	CDF	3	28	$1,077	$1,762

1 - Confined Aquatic Disposal (CAD), Confined Disposal Facility (CDF)
2 - The cost of the entire duration of the project in today's dollars.

Superfund Criteria Evaluation and Ranking

The alternatives were evaluated against seven Superfund criteria and ranked accordingly. Their ranking and relative scores are presented in the following charts.

Figure 22 Comparison of Draft FS Alternatives

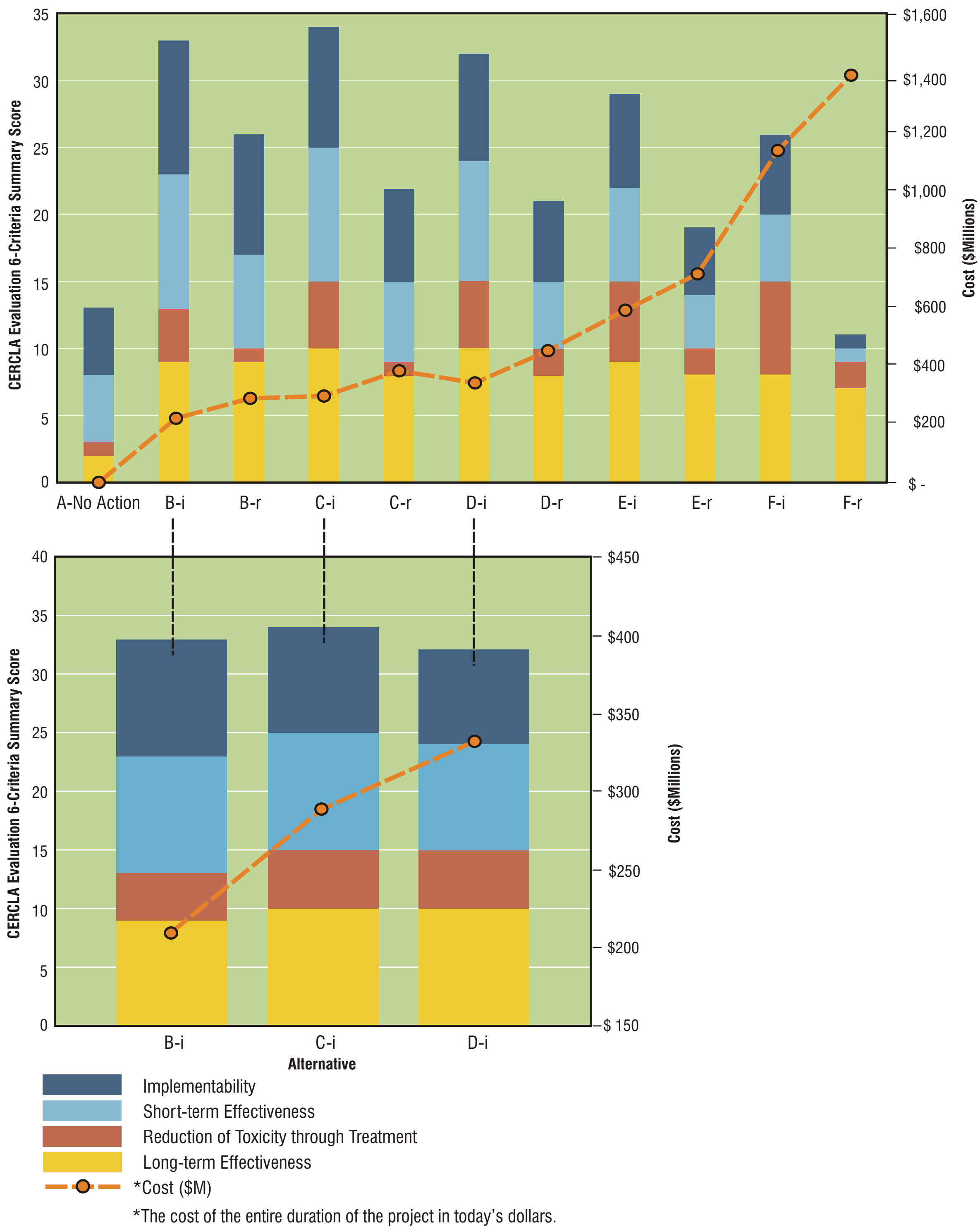


Figure 23 How the Alternatives Comply with Superfund Remedy Selection Criteria

Criteria	Results of the Draft FS Evaluation
Overall protection of human health and the environment	Over the long term, all of the comprehensive alternatives are projected to achieve similar levels for protection of human health and the environment. However, there are clear differences between the alternatives in terms of construction duration, short-term effectiveness, implementability and cost, and the draft FS evaluates those criteria.
Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)	Except for the "No Action" Alternative, all of the alternatives are in compliance with ARARs. EPA will determine whether surface water ARARs are met by the alternatives or whether waivers of certain surface water ARARs are appropriate due to background and other issues. The alternatives do not differ with respect to long-term projected post-remedy surface water concentrations, but Alternatives E and F have greater short-term impacts.
Long-term effectiveness and permanence	All of the action alternatives are projected to reach relatively similar and protective sediment COC concentrations over the long-term. The integrated alternatives (especially B-i, C-i and D-i) ranked higher than the other alternatives and are projected to provide lower site-wide average sediment and fish tissue concentrations throughout the next 30 years. The other alternatives, especially those that require removal of more acres of sediments, result in higher average concentrations of contaminants during this period.
Reduction of contaminant mobility, toxicity or volume achieved through treatment	Several of the alternatives propose the use of innovative in situ treatment technologies (e.g., treating sediment in place using material such as activated carbon) to reduce the bioavailability of a range of sediment contaminants.
Short-term effectiveness	Alternatives with more dredging have greater adverse short-term impacts on sediment, water and fish tissue over the construction periods, which can last up to 28 years for the larger alternatives. Alternatives with longer construction durations and greater dredge volumes present proportionately larger potential risks to workers (e.g. worker safety), the community and the environment (including water and air quality emissions), and therefore rank lower for short-term effectiveness factors: longer construction durations, increase equipment and carbon emissions, noise and other resource use. Dredging over larger areas also increases the short-term disturbance of the existing benthic community and other resident aquatic life via resuspension of contaminants and disruption of the community itself. Alternatives B-i, C-i, and D-i have far fewer negative short-term impacts compared to the other alternatives.
Implementability	Alternatives with shorter durations for construction would be easier to implement than those with longer construction periods. The shorter construction period reduces the overall level of difficulty, both technically and administratively (e.g., coordination with agencies), and the potential for technical problems leading to schedule delays. Alternatives B-i, C-i, and D-i were ranked the best for implementability.
Cost	Alternative F-r has the highest cost range (approximately \$1.07 - \$1.8 billion), and therefore ranks the lowest in this category. Alternative B-i has the lowest cost range (approximately \$169 - \$250 million), and therefore ranks the best in terms of cost.
State acceptance	This criterion will be considered by EPA when it prepares the Proposed Plan.
Community acceptance	This criterion will be considered by EPA when it prepares the Proposed Plan.

Key Findings of the Alternatives:

The detailed analysis of the alternatives determined the following:

- All of the comprehensive alternatives are expected to achieve similar reductions in contaminant concentrations and potential risk, based on the empirical data, analysis, and modeling presented in the draft FS.

- A sensitivity and uncertainty analysis conducted on the model confirms the model to be an effective tool for evaluating the relative performance of the comprehensive alternatives.

- Over the long-term, the overall protectiveness among the alternatives is similar, as reflected in the estimated concentrations of bounding COCs in surface sediments. This is due, in part, to the important influence of sedimentation and natural recovery on long-term COC concentrations.

- Alternatives B–F generally comply with federal and state ARARs. However, it is important to note that none of the alternatives are expected to attain all chemical-specific water quality criteria and standards for some COCs (particularly those based on fish consumption) because upstream concentrations entering the Site already exceed some of those criteria and standards. Fish consumption advisories are expected to remain in effect at the Site regardless of which alternative is selected.

- The major difference among the alternatives with successively lower RALs is that the extent of capping and dredging increases. Large remediation footprints (more acres of areas to be capped or dredged) increase the construction durations, short-term impacts to water quality, air and greenhouse gas emissions, community and worker risks, and disturbance of the existing benthic community and other resident aquatic life.

- MNR is a component of all the alternatives because it significantly contributes to the continued reduction of potential risks posed by contaminated sediments in the majority of the Site. The RI findings demonstrate it is recovering naturally in many areas via deposition of incoming sediments and other processes. The FS further applies an overall weight-of-evidence analysis using a combination of six independent lines of evidence to evaluate the effectiveness of MNR throughout the Site. Natural recovery processes are effective in reducing concentrations of contaminants in sediments, fish tissue and the water column.

- Focused cleanup actions and effective upland source control are expected to accelerate the rate of natural recovery.

- Enhanced monitored natural recovery (EMNR) further assists recovery by applying a thin layer of suitable material (e.g., sand) over cleanup areas.

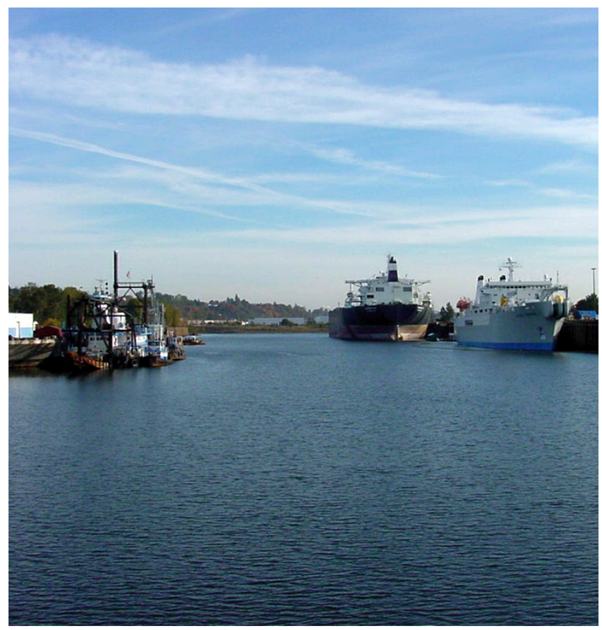
- The vast majority of buried contamination above the RALs is addressed through active remediation (e.g., capping and removal).

- Capping is effective at reducing potential risk by preventing erosion of buried contamination and is included in all of the comprehensive alternatives. This is supported by EPA's sediment guidance, which states the focus of remediation should be on risk reduction, not simply on contaminant mass removal.

- Removal-focused alternatives have greater short-term impacts than the integrated alternatives. Resuspension and dredge residuals cause elevated concentrations in sediments, fish tissue and the water column. Dredge residuals can be managed in part through process options such as placing sand covers after dredging. This finding is supported by experience at other large-scale sediment projects.

- Alternatives E-r and F-r are projected to result in higher surface water quality impacts and surface sediment concentrations following construction compared to those alternatives with more emphasis on EMNR/in situ treatment and capping. Resuspension of sediment and dissolved phase contaminant releases are generally more difficult to control, and findings from other projects indicate that barrier controls, such as silt curtains or sheet pile walls, do not reduce such releases.

- Alternatives requiring more removal of sediments have higher costs, are more difficult to implement, and have longer construction durations.
- Other impacts associated with lower RALs and increased dredging include:
  - More barge, rail and truck traffic associated with transport of dredged sediments to disposal facilities.
  - Increased risks to remediation workers during transportation, off-loading and disposal operations.
  - Exacerbation of factors affecting quality of life (e.g., odor, dust, noise and impacts to commercial navigation and recreational activities in the river).
  - Increased emissions of greenhouse gas and air pollutants associated with operation of construction equipment needed to implement the remedy.
  - More materials going to landfills and on-site disposal facilities.
- In summary, the integrated Alternatives B-i, C-i, and D-i rank higher than other alternatives because they provide a more cost-effective combination of overall risk reduction and lower short-term adverse impacts (e.g., impacts to sediments, fish tissue, and water quality).
- Of these three alternatives, Alternative B-i is protective for the least cost (i.e., it scored high in terms of short- and long-term effectiveness, reduction in toxicity, and implementability, while representing the lowest range of cost), while Alternative C-i scored the highest in terms of these criteria without consideration of cost.



Conclusion

The draft FS provides the necessary tools to guide the comprehensive sediment cleanup of the Portland Harbor Site. It is based on extensive data and provides the information and analyses necessary to fully support EPA's evaluation of the Superfund criteria and selection of a harbor-wide sediment remedy in the Proposed Plan.

General Findings

- An effective and efficient Portland Harbor sediment remedy should be coordinated with upland source control measures to reduce the potential sediment recontamination following cleanup.
- Multiple datasets and independent lines of evidence consistently indicate that the Site is predominantly depositional (supporting natural recovery potential) although deposition rates vary across the Site.
- Data evaluations were supplemented with a comprehensive predictive model to estimate the short-term construction impacts and long-term risk reductions resulting from each comprehensive alternative.
- Lessons learned from early removal actions in Portland Harbor, the region, and at similar sites throughout the United States have provided valuable information to further inform risk-based evaluations.
- The comprehensive alternatives evaluated in the draft FS were developed using RALs intended to achieve the RAOs and also the risk-based levels from the draft final BERA and BHHRA.
- Resident fish consumption advisories are in place for the entire Willamette River (including Portland Harbor), due to site and regional background conditions and upstream sources.
- The existing background conditions make it technically infeasible for any of the comprehensive alternatives to achieve the full range of total PCB RGs based on human health protection from consumption of resident fish.
- With the combination of on-going natural recovery and implementation of active remediation, surface sediment concentrations within the Site are expected to converge to levels similar to the quality of incoming sediment from upstream combined with other inputs, resulting in similar levels of risk over time within and upstream from the Site.
- While future conditions and actual concentrations could vary depending on the effectiveness of source control efforts, it is likely that surface sediment concentrations after active remediation and on-going natural recovery will be similar, regardless of which comprehensive alternative is selected.

Results of the Alternative Evaluation

- All of the alternatives (except for No Action Alternative A) are projected to be protective of human health and the environment.
- Differences in the overall protectiveness of the alternatives are largely due to short-term effectiveness, implementability, and in some cases the timing of substantial risk reductions that lead to achieving the range of risk-based RAOs.
- Uncertainties in RGs contribute the greatest amount of overall uncertainty in the projected outcomes of PCB remediation, while uncertainties associated with RAL, SMA, and alternative projections are relatively minor in comparison.
- Depending on what human health consumption scenario is selected as part of risk management, all of the alternatives (including the No Action Alternative A), could be measured to achieve within a one in one million to one in ten thousand cancer risk level (deemed acceptable by Superfund law).
- EPA can select the acceptable range of a remedial goal as a final cleanup level for a contaminant and have high confidence that the risk reduction goal will be met because that entire range is deemed protective (i.e., 90-percent to 99-percent confidence range).

- The comprehensive alternatives with lower RALs and greater dredge volumes would provide less overall effectiveness, because they would generate more releases of bioavailable contaminants over significantly longer construction durations and at greater cost.

- The risks associated with implementing a dredging remedy include unavoidable contaminant resuspension and releases during sediment removal, continued exposure to contaminants during the construction and implementation phases, residual contamination, disruption of the benthic community, worker risk during sediment removal and handling, and community impacts including accidents, greenhouse gas emissions, and quality of life considerations. Further, these risks all become greater as the footprints of the alternatives and volume of dredging increases.

- All of the comprehensive alternatives would require a set of controls consisting of monitoring, maintenance, institutional controls, and periodic reviews (e.g., every five years).

- The integrated alternatives include more potential for in situ treatment, and therefore rank higher with respect to the treatment criterion than removal-focused alternatives.

Figure 24 Draft Numeric Summary of Comparative Analysis of Remedial Alternatives

			Balancing Criteria						
Alternative	Threshold Criteria		Effectiveness Criteria			Implementability	Summary Score Balancing Criteria	Cost ($M)	
	Overall Protection	Meets ARARs	Long-term Effectiveness	Reduction of Toxicity through Treatment	Short-term Effectiveness			Low[3]	High[3]
A - No Action	No[1]	No	2	1	5	5	NA	$ -	$ -
B-i	Yes	Yes[2]	9	4	10	10	33	$169	$250
B-r	Yes	Yes[2]	9	1	7	9	26	$228	$330
C-i	Yes	Yes[2]	10	5	10	9	34	$231	$345
C-r	Yes	Yes[2]	8	1	6	7	22	$304	$449
D-i	Yes	Yes[2]	10	5	9	8	32	$266	$398
D-r	Yes	Yes[2]	8	2	5	6	21	$351	$520
E-i	Yes	Yes[2]	9	6	7	7	29	$463	$709
E-r	Yes	Yes[2]	8	2	4	5	19	$568	$884
F-i	Yes	Yes[2]	8	7	5	6	26	$878	$1,389
F-r	Yes	Yes[2]	7	2	1	1	11	$1,077	$1,762

1 - Alternative A - No Action is protective for some portions of the Site.

2 - With respect to surface water ARARs, EPA will determine whether the alternatives meet those ARARs with respect to contamination that will remain on Site or whether waivers of certain surface water ARARs are appropriate due to background and other issues. As discussed in Section 9 of the draft FS, the alternatives do not differ with respect to long-term projected post-remedy surface water concentrations.

3 - The cost of the entire duration of the project in today's dollars.

NA - Not applicable. Alternative does not meet threshold criteria.

Legend:

>30 – Highly Effective
26-30 – Effective
20-25 – Somewhat Effective
<20 – Least Effective

Results of the Cost Effectiveness Evaluation

- All of the comprehensive alternatives ranked similarly with respect to the overall evaluation of long-term effectiveness and permanence.

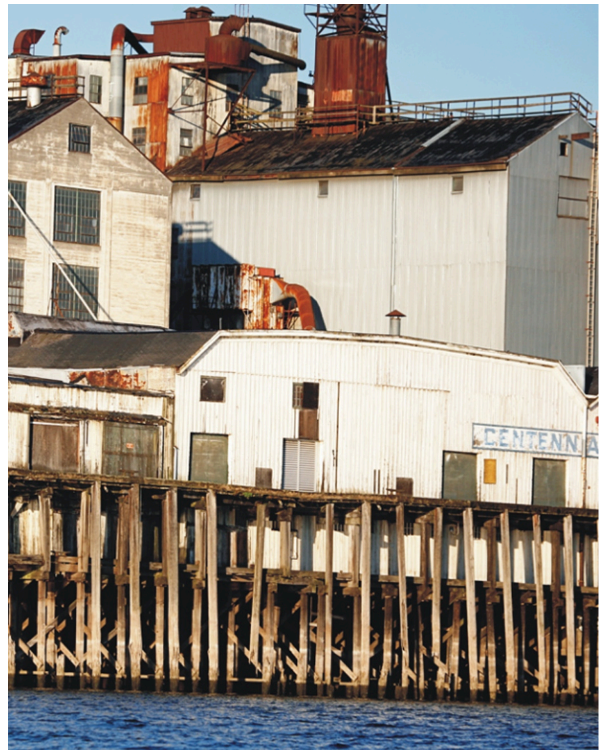
- The integrated alternatives (especially Alternatives C-i and D-i) ranked higher than the other alternatives as they would provide a higher level of overall risk reduction and lower residual risks than the more removal-focused alternatives.

- Alternatives B-i and C-i ranked higher than other alternatives for short-term effectiveness.

- The greatest degree of overall effectiveness is achieved under Alternatives B-i, C-i, or D-i, which correspond to a total cost of approximately $169 to $398 million and construction duration of approximately two to three years.

- Alternatives B-i, C-i and D-i have the highest Summary Score and are the three alternatives that best meet both the RAOs and the seven NCP criteria. These three alternatives are distinct from the remaining alternatives in achieving adequate protectiveness in substantially shorter durations.

- Alternative B-i is protective for the least cost, and Alternative C-i scores the highest without consideration of cost.



Acronyms and Glossary

AOC	**Administrative Order on Consent:** A legal document signed in 2001 by EPA and ten members of the Lower Willamette Group who agreed to perform the Remedial Investigation and Feasibility Report phase of the Portland Harbor Superfund project.
AOPCs	**Areas of Potential Concern:** The broadest identification of the areal extent of potentially unacceptable contaminant levels in sediments.
ARARs	**Applicable or Relevant and Appropriate Requirements:** Applicable requirements mean those cleanup standards, standards of control, or other substantive environmental protection requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance found at a CERCLA site. The relevant and appropriate requirements relate to standards, controls, or other substantive criteria or limitations that do not directly and fully address site conditions, but address similar situations or problems encountered at a Superfund site.
Bathymetry	The detailed mapping of the depth and topography (terrain) of the river bottom.
BaPEq	**Benzo[a]pyrene Equivalent:** A polycyclic aromatic hydrocarbon (PAH) found in petroleum products
Benthic	Relating to or characteristic of the bottom of a water body or the organisms and plants that live there.
BERA	**Baseline Ecological Risk Assessment:** The process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors, including chemicals.
BHHRA	**Baseline Human Health Risk Assessment:** The process that evaluates the likelihood that adverse human health effects may occur or are occurring as a result of exposure to one or more stressors, including chemicals.
Biota	The total collection of organisms of a geographic region.
CAD	**Confined Aquatic Disposal:** An engineered in-water disposal facility for containment of dredged contaminated sediments. The dredged sediments are placed in a submerged location and capped (covered) with clean material. CADs are designed and placed in locations where they will always be completely underwater. The thickness of the cap and the grain size of the clean sediment are designed to prevent contaminants from migrating back into the aquatic environment.
CDF	**Confined Disposal Facilities:** An engineered structure for containment of dredged material. The confinement dikes or structures in a CDF enclose the disposal area, with the top of the CDF above any adjacent water surface, isolating the dredged material from adjacent waters during placement.

CAG **Community Advisory Group:** A Portland Harbor Community Advisory Group was formed in 2001 to enhance public participation in the cleanup process by providing a public forum where community representatives can discuss their diverse interests, needs and concerns.

CERCLA **Comprehensive Environmental Response Compensation and Liability Act:** The 1980 federal law commonly known as Superfund, authorizes EPA to respond to releases, or threatened releases, of hazardous substances that may endanger public health, welfare, or the environment.

COCs **Contaminants of Concern:** Contaminants identified through the baseline risk assessment that potentially cause unacceptable adverse effects to human health and/or ecological receptors

CSM **Conceptual Site Model:** A written and/or schematic representation of an environmental system and the physical, chemical, and biological processes that determine the transport of chemicals from sources through environmental media to humans and ecological receptors in the system. The CSM is often revised periodically as additional data become available at a site.

DEQ **Department of Environmental Quality:** The State environmental agency that is the lead agency for upland cleanup sites and source control for the Portland Harbor Superfund Site.

DDD **Dichlorodiphenyldichloroethane:** A breakdown product of DDT

DDE **Dichlorodiphenyltrichloroethylene:** A breakdown product of DDT

DDT **Diphenyl-trichloroethane:** A pesticide

DDx The term used for the combined concentrations of DDD, DDE and DDT

EMNR **Enhanced Monitored Natural Recovery:** The application of engineered means such as thin-layer placement of capping material to accelerate natural recovery processes.

EPA **Environmental Protection Agency:** United States agency that is the lead agency for in-water sediments and near shore areas of the Portland Harbor Superfund Site.

FS F**easibility Study:** The Feasibility Study is the report that summarizes the development, screening and detailed evaluation of alternative remedial actions.

HI **Hazard Index:** An indication of the potential for cumulative noncancerous effects that is derived by summing individual hazard quotients for two or more chemicals. HI values below 1 indicate a negligible hazard. HI values above 1 indicate a potentially unacceptable hazard.

HQ	**Hazard Quotient:** An indication of the potential for adverse effects other than cancer from a given chemical calculated by dividing an estimated exposure (dose or concentration) by a toxicity reference value or reference dose. HQ values below 1 indicate a negligible hazard. HQ values above 1 indicate a potentially unacceptable hazard.
ICs	**Institutional Controls:** Institutional controls are non-engineered instruments, such as administrative and legal controls, that help minimize the potential for human exposure to contamination and/or protect the integrity of the remedy. An example would be an advisory on fish consumption.
LOEs	**Lines of Evidence:** A specific analysis approach, based on empirical data or a model prediction that is used to assess potential risks to humans or ecological receptors.
LWG	**Lower Willamette Group:** The ten parties who signed an agreement with EPA to conduct the remedial investigation and feasibility study of the Site and four other parties who have contributed financially to the project. The LWG is a small subset of potentially responsible parties identified by EPA for the Portland Harbor Superfund Site.
MNR	**Monitored Natural Recovery:** A process of monitoring the ability of a water body, sediment, or beach to clean itself up through natural processes.
NCP	**National Contingency Plan:** The federal government's blueprint for responding to oil spills and hazardous substance releases. The NCP is the regulatory framework for the Superfund cleanup process.
PAHs	**Polycyclic Aromatic Hydrocarbons:** A group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances.
PCBs	**Polychlorinated Biphenyls:** A class of synthetic chemicals that were in numerous and various industrial materials and products, and in transformers and other electrical equipment.
PRGs	**Preliminary Remedial Goals:** A chemical concentration in a specific medium (e.g., sediments and water) that should meet acceptable risk levels.
PRPs	**Potentially Responsible Parties:** Any individual, company, or agency who may be liable for contamination at a Superfund site.
RALs	**Remedial Action Levels:** The point concentration of contaminants in sediment that define the areas of active remedial action for each alternative in the FS.
RAOs	**Remedial Action Objectives:** The narrative objectives that indicate what sediment cleanup remedies should accomplish to reduce potential risks to human health and environment.
RGs	**Remedial Goals:** The numeric concentrations of contaminants intended to meet the RAOs and used to assist in evaluating the remediation alternatives.

RI **Remedial Investigation:** The report that describes the nature and extent of contamination, characterizes physical conditions and the potential movement of contaminants, and assesses the potential risks that contamination may pose to human health and the environment.

RI/FS **Remedial Investigation and Feasibility Study:** The combination of the remedial investigation report (RI, see definition), and the feasibility study report (FS, see definition).

ROD **Record of Decision:** The public document that explains which cleanup alternative(s) will be used to clean up a Superfund site. The ROD is issued by EPA based on the RI/FS and input from the public and the state on the Proposed Plan.

SMAs **Sediment Management Areas:** Areas of sediments that exceed RALs (see definition), and are segregated into discrete units for the purposes of identifying and evaluating remedial technologies in the feasibility study.

SOW **Statement of Work:** The document attached to the Administrative Order on Consent between the EPA and the LWG that describes the deliverables required for the RI/FS process.

Study Area The stretch of the Lower Willamette River from Sauvie Island to north of downtown Portland (approximately River Mile 2 - River Mile 12).

Superfund The EPA program that addresses both emergency removal and long-term remedial activities for contamination by hazardous chemicals. The Superfund program includes investigating sites for inclusion and ranking on the National Priorities List, and conducting and/or supervising cleanup and other remedial actions.

SWACs **Surface-area Weighted Average Concentrations:** The average concentration of contamination in the upper one-foot of sediment over a particular area (e.g., per river mile).

TEQ **Toxicity Equivalent:** The sum of a series of multiplicative products, each consisting of the concentration of an individual PCB or dioxin/furan congener multiplied by its Toxicity Equivalent Factor.

TRV **Toxicity Reference Value:** A chemical concentration (or dose) threshold that represents some level of documented effect on a particular organism from exposure to the chemical (i.e., the minimum concentration at which adverse effects have been observed, or the maximum concentration at which no adverse effects have been observed).

For More Information on the Draft Feasibility Study Report go to:

www.lwgportlandharbor.org

LWG
Lower Willamette Group